Volume XXV. Number 1.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

JANUARY, 1925

TABLE OF CONTENTS

Crop Ecology and the Primary Vegetational Survey—*A. E. Waller* 1

A Review of the Genus Eristalis Latreille in North America—
Frank M. Hull 11

Four Undescribed Species of Waterstriders (Hemip.-Gerridæ)—
C. J. Drake and F. C. Hottes 46

Published by the

OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2 00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

Volume XXV. Number 2.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

MARCH, 1925

TABLE OF CONTENTS

Physiographic History of Five River Valleys in Northern Ohio—
George D. Hubbard and Milton M. Champion.............. 51–84

The Chicory Family in Ohio—*Nellie F. Henderson*............. 85–96

Notes on the Occurrence of Glacial Material Beyond the Border of the Drift in Muskingum County, Ohio—*LeRoy T. Patton and Clifford Hicks*.................................... 97–98

Published by the

OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2.00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

EDITOR

FREDERICK H. KRECKER

Associate Editor..................JAY B. PARK

Business Manager...........LEWIS H. TIFFANY

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

Volume XXV. Number 3.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

MAY, 1925

TABLE OF CONTENTS

Some Considerations of Protoplasm—*Bruce Fink* 99
Some Observations of a Plant Collector on the Island of Hainan—
F. A. McClure 114
Descriptions of Fourteen Undescribed Species of Parthenicus
(Hemiptera, Miridæ)—*Harry H. Knight* 119
Additions to the Catalog of Ohio Vascular Plants for 1924—
John H. Schaffner 130
The Natural Vegetation of Ohio. Part I—*Paul Bigelow Sears* ... 139

Published by the
OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2.00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

Volume XXV. Number 4.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

JULY, 1925

TABLE OF CONTENTS

Report of the Thirty-Fifth Annual Meeting of the Ohio Academy of Science—*W. H. Alexander* 151
The Influence of the Substratum on the Percentage of Sex Reversal in Winter-Grown Hemp—*John H. Schaffner* 172
Ohio Mosses, Polytrichiales—*Nellie F. Henderson* 177
Synapsis Considered as a Sexual Phenomenon—*John H. Schaffner* 183
The Dragonfly, Tachopteryx Thoreyi, Recorded for Ohio, with Notes on its Near Relatives—*James S. Hine* 190
The Genus Debarya—*Edgar Nelson Transeau* 193

Published by the
OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2.00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

Volume XXV. Number 5.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

SEPTEMBER, 1925

TABLE OF CONTENTS

Digestive Enzymes of an Insect—*H. S. Swingle* 209
Principles of Plant Taxonomy, II.—*John H. Schaffner* 210
The Digestive Tract of Longistigma Caryae (Harris)—*George F. Knowlton* 244
Insect Food Habit Ratios in Death Valley and Vicinity—*Harry B. Weiss* 253

Published by the
OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2.00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

Volume XXV. Number 6.

THE OHIO JOURNAL OF SCIENCE

Official Organ of the Ohio Academy of Science and of the
Ohio State University Scientific Society

NOVEMBER, 1925

TABLE OF CONTENTS

A Study of the Cestode Parasites of the Black Bass in Ohio, with Special Reference to their Life History and Distribution—*Ralph V. Bangham*.......... 255

The Carrot Family in Ohio—*Nellie F. Henderson*.......... 271

A Review of the Genus Eristalis Latreille in North America—Part II—*Frank M. Hull*.......... 285

Aphids New to Ohio—*C. R. Cutright*.......... 313

Index to Volume XXV.......... 315

Published by the

OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY
COLUMBUS

Annual Subscription, $2.00 Single Number, 50 Cents

Issued Bi-monthly, January to December (six numbers)
Entered at the Post-Office in Columbus, Ohio, as second-class matter

THE OHIO JOURNAL OF SCIENCE

EDITOR

FREDERICK H. KRECKER

Associate Editor...................JAY B. PARK

Business Manager...........LEWIS H. TIFFANY

Manuscripts.—THE OHIO JOURNAL OF SCIENCE is devoted to the publication of articles dealing with any branch of science. Contributions will be received without respect to membership in the Ohio State University Scientific Society or the Ohio Academy of Science. Manuscripts are subject to the approval of the editor. Articles covering not more than fifteen pages will be given preference, although longer articles may be printed. The cost of cuts and of all reprints must be borne by the contributor.

All manuscripts and correspondence dealing with editorial matters should be addressed to the editor.

Business Matters.—THE OHIO JOURNAL OF SCIENCE is owned and controlled by the Ohio State University Scientific Society. By a special arrangement with the Ohio Academy of Science, the OHIO JOURNAL OF SCIENCE is sent without additional expense to all members of the Academy who are not in arrears for annual dues.

Annual subscription to foreign countries is $2.50.

The first fifteen volumes of the old OHIO NATURALIST may be obtained at $1.00 per volume.

All business communications should be addressed to the Business Manager.

Remittances of all kinds should be made payable to LEWIS H. TIFFANY, Business Manager.

Address.—The address of both the Editor and the Business Manager is

THE OHIO JOURNAL OF SCIENCE, Ohio State University, Columbus.

THE OHIO
JOURNAL OF SCIENCE

Official Organ of the

OHIO ACADEMY OF SCIENCE

and of the

OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY

VOLUME XXV — 1925

OHIO STATE UNIVERSITY

COLUMBUS

THE OHIO JOURNAL OF SCIENCE

VOL. XXV JANUARY, 1925 No. 1

CROP ECOLOGY AND THE PRIMARY VEGETATIONAL SURVEY.*

A. E. WALLER,
Department of Botany, Ohio State University.

At a meeting of Agricultural Experiment Station workers, it seems fitting to quote a statement made at the British Association meeting recently by the Director of Rothamstead, (8). In discussing the organization of the experiment stations to meet the problems of crop production and the complexity of the results furnished by various members of the staffs, he asks, "What is the purpose of it all? Team-work, co-operation, the great expenditure of time and money now being incurred in agricultural science and experiment, these are justified only if the end is worthy of the effort. The nineteenth century took the view that agricultural science was justified only in so far as it was useful. That view we now believe to be too narrow. The practical purpose is of course essential; the station must help the farmer in his daily difficulties—which again necessitates co-operation, this time between the practical grower and the scientific worker. But history has shown that institutions and investigations that tie themselves down to purely practical problems do not get very far."

A bird's eye perspective of the work at experiment stations all over the country seems to indicate that a number of them are offering the daily bread of empiricism without much scientific jam on it to meet the daily difficulty. A number of them and fortunately an increasing number each year devote their best talent to the investigation of fundamental problems. It is my purpose to try to sketch some of the fundamental problems of crop ecology, not so much pointing out specific problems, but instead attempting to outline them.

---

* Papers from the Department of Botany, the Ohio State University, No. 150. Read at the Ohio Agricultural Experiment Station, November 3, 1924.

Remembering the great scope and tremendous complexity of the problems which the agriculturalists must face, we can put up a defence without shame for the use of some empirical methods of attacking these problems. If by empiricism be meant a trial and error method we cannot reject it altogether in spite of its cumbersomeness and expense, for a strictly logical method of attack. The reason is plain enough. There are so many unknown quantities in all biological phenomena. The mathematician has the advantage of assuming certain conditions and handling his unknown quantities piece-meal. The agriculturalist must face his unknowns all massed within the living plant. He is forced to make deductions from experiments which he may find impossible to duplicate exactly. He must therefore expect to get his best results from a combination of empirical and scientific methods.

How, you may ask, does this relate to any of the problems of crop ecology? In its broadest sense this would include all of the problems of agriculture as we are now facing them, both to meet the present difficulties of a practical grower and the broad general needs of the people of our State of Ohio. If all the problems which we face could be massed into one, we would instantly perceive that crop ecology is the central scientific basis upon which to build and that the keystone problem is *adaptation.*

Now by adaption in our crop plants we do not necessarily have in mind the same kinds of adjustments merely that we have in the native and naturalized plants of a region. It is sufficient for the native plants that they are not killed in the winter or burned by the summer's drouth, that the soil supplies the water and minerals needed, that their enemies are not so numerous or so persistent that they cannot outgrow them, that they ripen seeds or store food in vegetative organs. In perennials it is not even necessary to ripen seeds each year. In our crop plants on the other hand, not only must the plant produce some desired product, but this yield must be produced in a given season and must be of a marketable quality if the plants are to return a profit to the grower. The highest yielding wheats are not always the most desirable. Milling and baking tests must be made to show whether the plant is suited to consumers demands as well as the growers' interests. A dwarfed timothy plant would be a menace if it also happened

to produce seeds very abundantly. A common barberry bush of any color is accursed. Flax and hemp, formerly acceptable and suited to both the soils and climate of the state have practically disappeared. Clover failure presents an acute farm problem in our older agricultural sections. All of these instances indicate that we must look to the kind of product and to its quality before determining whether or not our crop plants are adapted. The work of the plant breeder and of the ecologist must be co-ordinated. We can expect permanent advances in our agricultural position only in proportion to the amount of linked effort that is made.

Briefly, we have variables in the plant and in its surroundings. In both the interior of the plant and in its environment we are, within limits, able to exercise some control. We call the facts relating to the interior of cells of plants its heredity and we hide our ignorance of the way these inherited characteristics may descend from one generation to another in the terminology of genetics. We classify the groups of factors that surround the plant and modify the expression of its heredity as climatic, edaphic and biotic, and we are led away by some words into thinking that our case can rest. But we often fail to synthesize observations and experiments made in these groups of facts and apply them. Here is where our true problem of adaptation comes in and where the ecology of our crops will find its real phase of usefulness—interpreting the results, because of the methods of analysis.

Let me take an example, from our agricultural history, of an empirical method of meeting a pressing need. Cotton was reported in 1789 to be growing successfully at Marietta. Moreover, the colony had some surplus product which was advertised for sale in Paris. Cotton was grown until 1840 as one of the crops of Lawrence County. While no one could now think of growing cotton in Ohio, starting with the seeds of the plants at the present time grown in Southern States, who knows but that we lost a most valuable agricultural plant by failing to maintain an interest in what is a most unique phase of a great industry. The empirical method led to a valuable result, but after commercial contact between the states was on a firmer footing the pioneer industry died away for lack of interest.

Rice also was grown by the Marietta pioneers, but it seemed less promising and certainly was less needed than cotton.

It might be mentioned in passing that a native industry in growing our wild rice grass may yet offer possibilities, since it has already been introduced into some markets as a variant in our diets. Mention is made of this to show that while the pioneers practiced their own empiricisms, they were not willing to learn from the experience of the Indians the use of native plants.

In contrast to this type of empirical method let us consider another. This has to do with a distributional problem in which but one factor in the environment of the plants was employed as a means of showing graphically plant distribution. This factor is one that is directly related to growth, but is not so directly related to geographic distribution. The scheme proposed by the directors of the biological survey is the one which employed only the single factor, temperature, to indicate plant and animal distribution. Within a short while after it was proposed, a number of ecologists, Adams, Shelford, Cowles and Transeau among them, pointed out its fallacy. However, it has not stopped the Survey from using its own method, nor a great many people from employing terminology used at that time. The principal paper on the subject was by Dr. C. Hart Merriam (7) and called "Life Zones and Crop Zones." In one section called "Laws of temperature control of geographic distribution of animals and plants," it is stated that temperature is the most important single factor, apart from mechanical barriers, in fixing the limits beyond which certain species cannot go. The United States is divided into a series of zones with bands running east and west and named, Boreal, Transition, Upper Austral, Lower Austral, Gulf strip of the Lower Austral, and Tropical. These zones are obtained along the isotherms made by connecting, on a large map of the U. S., the stations where the sums of the positive temperatures are the same during the season when the mean daily temperature is about 60 c. No accounting for moisture is allowed, though the plan divides the Eastern half of the United States into a region called humid, and the Western half, while not designated, is presumably arid, with no account taken of the region of highest rainfall in the United States, on the Northwestern Coast. It is most remarkable that this should have obtained much credence with biologists in North America. Not only is it still reported in all the biological survey publications, but even some of our

Canadian Naturalists have made use of the terminology as late as the current year. Lloyd in a paper on the vegegation of Canada has continued to use the terminology with the plea that it is well known. Unfortunately its fault of being based on a single factor of the environment is not well enough known. What does it lead us to? To take the zone designated as Upper Austral as an example, it embraces the Atlantic Coast from Connecticut to the Potomac River; the Western, but not the Eastern half of Long Island, the Hudson River Valley; it extends Southwest from Maryland to Alabama and West to Northeastern Montana, nearly to the Canadian border and south through the Mexican State of Durango. It would lump together such distinctive types of vegetation as our Eastern deciduous forests, the prairies, the plains, and some of the semi-arid regions in New Mexico and Mexico. The Lower Austral includes the coast of Virginia, the Mississippi Valley on the Western boundary of Kentucky and Lower California. The species or the groups of species in these regions are certainly not closely related to each other. With the crop plants such an unfortunate attempt to bolster up misapprehension of the fact appears as in the statement, "that while corn is no exception to the fact that cereals thrive best in cool climates, most of the varieties are found in the lower Austral zone."

Is it any wonder then that with the impetus that has been given to the promulgation of this particular misconception that the Experiment Stations have not taken into serious account of the work of those of the ecologists whose ideas of the distribution of plants and animals have been more conservatively formed and offered with some reserve and many exceptions pointed out as to geographic detail?

In order to study distribution it is necessary to take some measure to account of all of the factors of the environment. There is no empiricism about this. It is simply a record of observation. And as the record is a long one many conservative ecologists—notably Tansley, Cowles and others still emphasize the need of more descriptive ecology. This does not mean a mere listing of the plants in a given area, but a definite attempt to show the relations existing between environmental factors and the development of a particular association of plants. There is no definite border line between the best type of descriptive ecology and the beginning of experimental ecology.

For in the end experimental ecology is the interpretation of scientific observation.

Much better schemes than Merriam's for showing graphically the underlying causal factors of the geographic distribution of vegetation and of animal life have been worked out. They all employ combinations of factors instead of a single factor. Among such are Livingston's Moisture—Temperature charts and Shreve's ratio of soil moisture to evaporation and Transeau's Rainfall-Evaporation chart, (10). Livingston and Shreve (5) in discussing the Rainfall-Evaporation chart state: "The importance of the moisture ratio in controlling the leading vegetations was shown by Transeau for the Eastern United States, and our investigation has served to confirm his deductions as well as to extend their application to the entire country. The comparisons which have been made between the vegetational areas and the various other climatic conditions have served to emphasize the moisture ratio even more than was done by Transeau, since no other single datum has been found in our work to approach it as an expression of the controlling conditions for forest, grassland and desert."

Long ago Asa Gray called plants the thermometers of the ages. That is still a good statement. One of the ways in which we can apply the accumulating knowledge of the distribution of vegetation and the physical factors which underlie this distribution is in mapping out the distribution of our crop plants. The familiar work of Shantz on the indicator significance as to the capabilities of land for crop production represents an appreciation of the fact that a living plant growing in a particular habitat is often the most accurate way of measuring the environment. Clements (2) work on Plant Indicators is of much value for reference and research, especially being a record of observations in the Western sections of the United States.

A classic example of the correlation of the work of several ecologists who have studied a single region is to be found in a series of papers by Kincer (4), Marbut (6), Shantz (9) and Baker (1) on the Great Plains. These authors respectively discuss the climate, soils, vegetation and types of farming of the Great Plains region. As is to be expected, there are marked correlations to be found between the physical factors of the environment, the vegetation, and the crop plants that can be grown. It represents a wonderful Synthetic study of a region that should be duplicated for the various sections of the country

as a primary survey undertaken before making permanent or radical changes in an already existing system of agriculture Shantz divides the Plains into four sections as follows:

A. Land primarily valuable for crop production. In this section needle grass and slender wheat grass are indicators of the possibilities for spring wheat and the spring cereals; Bluestem bunch-grass indicating winter wheat, corn and alfalfa and mesquite and mesquite grass indicating cotton and grain sorghums.

B. Land valuable for crop production and grazing with crop failure when the rainfall is less than normal. Grama and western needle grass indicate spring wheat and other spring grain; wire grass indicates winter wheat, corn, and in the south the grain sorghums; wheat grass indicates spring grains and corn; and grama and mountain sage indicates spring grains.

C. Land valuable for grazing and crop production; good crops only during years of more than normal rainfall. Grama and buffalo grass indicate grain sorghums corn and small grains. Mesquite grass and thorn bush indicate cotton and grain sorghums during good years only. Sand sage and sand grass indicate corn and sorghum except in the southwest and grams grass indicates spring grains during the good years.

D. Land valuable for grazing only is indicated by sagebush, western wheat grass and Blackgrama.

Baker points out that often settlers unacquainted with the nature of the region try the wrong types of farming, and that sixteen hundred acres often can produce no more than 160 acres in the Eastern States. Marbut shows the importance of an examination of a soil profile so that the underlying soil as well as the topmost layer may be used to indicate the kinds of plants that may be grown.

Putting it briefly, we seem to be justified in making a strong case for the dynamic role played by the plants. For the climatic conditions are not varying, the soil not greatly varying. The extremes in the distribution of rainfall over a period of many years, not the seasonal rainfall, determine the native vegetation and the humus has largely determined the soil conditions. Some years ago the writer (11) made use of the *E* ratio of Transeau to show graphically the general features of the distribution of our crop plants. It is very gratifying to see that the detailed studies of the Great Plains discussed above bear out in the main the location of crop centers as deduced from a study of the rainfall evaporation ratio.

In the Eastern part of the United States with a higher content of soil moisture, the evaporation rate has been shown by a number of ecologists to be correlated with distribution. Of the greatest interest is the growth of our crop plants under field conditions with a daily record of the water loss. This has not been used as yet to the extent of its possibilities in indicating the correlations between moisture and yields.

Following the work of Garner (3) and Allard, light, too, must come into an added place of importance from the standpoint of photoperiodism. The older work has long recognized light intensity in relation to photosynthesis, and light intensities in relation to transpiration, by which it is tied up in a complicated way with both moisture and temperature factors. The new point calls attention to the direct effect of the length of the day. The significance has already been pointed out with a number of crop plants. Thatcher at the Ohio Station found that the planting dates of wheat vary somewhat with the latitude. Wanser has stated that photoperiodism is the key to the distinction between spring and winter wheats. Adams has shown that in both wheat and rye light, is, with heat in the greenhouse, important in controlling the date of heading out of the different varieties. For the explanation of spring and winter cereals we must look to an inherent rhythm in the plants adjusted to the peculiar Mediterraeann climate where these plants have long been grown. In the Mediterranean type of climate we may observe two cool moist growing seasons, the spring and autumn. There are also two dormant periods, the hot summer, too dry for plant growth, and the moist winter, too cool for plant growth. Winter wheat and rye have swung into this rhythm by growing in the fall and spring—the short day periods, and blooming in long day periods of early summer. Spring wheat lacking the autumn vegetative period has its vegetative activity telescoped and has consequently stored a less quantity of carbohydrates before blooming. Corn, on the other hand, represents a short day reproductive type. It has been modified by years of selection by the American Indian in carrying it northward from central America until there are some varieties which begin blooming a few weeks after the summer solstice. In winter time in the greenhouse we can have corn blooming in from five to seven weeks after it has been planted. Some selections of early blooming varieties of corn have been made at the Ohio Experiment Station. Potatoes show the same

response to light periodicity in different latitudes. Halves of the same tubers which bloomed and set seed at Presque Isle, Maine, did not open any flowers at all in the New York Botanical Gardens.

Turning now to some of the biotic factors, the foresters know that certain groups of plants often do well when the same plants separated and grown in the open would not thrive. There is undoubtedly something gained by combining certain plants in attempting to obtain growth returns. Passing over the many varied explanations, let us look at certain suggestive experiments. At the Minnesota Station, Arny has recommended under certain conditions the combination of wheat and flax when the latter is grown for its seeds. At the Ohio Station there seem to be benefits under certain conditions resulting from combining corn and soy beans. Just as with the other factors studied there are a great many problems that need to be solved in the biotic groups as well as in the climatic and edaphic problems, all relating to adaptation. Other examples of biotic factors that have been studied in a very intensive way may be drawn from the many plant pests that produce crop yields. So definitely localized are many of the resistant varieties that in two parts of the country where the same crop may be grown, a variety found to be successful at one place is found to be perfectly worthless at the other. It seems in the interests of adaptation, therefore, that the wise plan for experiment stations over the country would be to carry on some interchange of their discards, (as in the game of rum), just as well as to exchange their more valuable selections.

One advance step that can be carried on by the co-operated activities of the Ohio Experiment Station and the University would be to undertake a complete primary survey of the vegetation of Ohio. In the State Herbarium are deposited many plants which are not any longer found in the counties in which they once were native. There are also records of the original surveys of the State in the State House and there is the group of field workers who have opportunity to make contributions to the ecology of Ohio by their observations in Forestry and Crops at the Station and at the University. It would mean much, not in any immediate practical way, but in a fundamental way, to the future development of the Agriculture of the State if all of this information could be compiled and

edited and serve as the basis for recommendations as to future experimental work and also a good basis for practice. Local botanists with training in field work could co-operate with the staffs of the Experiment Station and the University to their mutual advantage. Thus with the formation of a central committee, a plan for mapping the vegetation of the entire State should be proposed. The types of vegetation already studied and the mapped areas should be examined and so furnish suggestions for proceeding with the art of the work. For we will only be able to formulate problems in general ecology and in our crop ecology after we have mapped definitely the vegetation of our area, as the first requisite is a certain number of accurately observed and recorded facts. The floristis studies made a quarter of a century and more ago will not suffice. The problems there were of discovering species, but now they consist of evaluating the physical factors that control the grouping of plants into associations.

If the work of such a committee as outlined were carried out, Ohio would be taking a step forward that would not only contribute to a knowledge of the vegetation of the world. This survey, when combined with our knowledge of physiology, pathology and genetics would offer the key to many of our most important problems of adaptation.

LITERATURE CITED.

1. Baker, O. E. 1923. The agriculture of the Great Plains Region. Annals Assoc. Am. Geog. 13:109.
2. Clements, F. E. 1920. Plant Indicators. Carnegie Institution of Washington Pub. 290.
3. Garner, W. W. and Allard, H. A. 1920. Effect of the relative length of day and night and other factors on growth and reproduction in plants. Jour. Agr. Research, 18:553.
4. Kincer, Joseph B. 1923. The climate of the Great Plains as a factor in their utilization. Annals Assoc. Am. Geog. 13:67.
5. Livingston, B. E. and Shreve, Forrest. 1921. The distribution of vegetation in the United States as related to climatic conditions. Carnegie Institution of Washington Pub. 284.
6. Marbut, C. F. 1923. Soils of the Great Plains. Annals Assoc. Am. Geog. 13:41.
7. Merriam, C. Hart. 1898. Life Zones and Crop Zones. U. S. Dept. of Agric. Bul. 10.
8. Russel, Sir John. 1924. The Advancement of Science. (Address, Annual Meeting Brit. Assoc.)
9. Shantz, H. L. 1923. The natural vegetation of the Great Plains Region. Annals Assoc. Am. Geog. 13:81.
10. Transeau, E. N. 1905. Forest centers of Eastern North America. Am. Nat. 39:875.
11. Waller, A. E. 1918. Crop centers of the United States. Jour. Am. Soc. Agron. 10:49.

A REVIEW OF THE GENUS ERISTALIS LATREILLE IN NORTH AMERICA.

FRANK M. HULL
Ohio State University.

Introduction.

In many ways a treatment of the North American species of the genus *Eristalis* is much to be desired. This is especially true of certain groups of species, the separation of which have long perplexed students of the family. Several studies have been presented in the past, but these have treated of a limited number of forms. The Ohio State University collection is particularly rich in species of the genus and, at the suggestion of Professor J. S. Hine, the writer was led to take up the study of the group, a study that has been carried on intermittently over the last two years. Although opportunity was afforded to study good series of many forms known hitherto from but few specimens, the work is still necessarily incomplete. First, there remain a considerable number of species on the lists, not recognized since they were described, and secondly, although few species have been described in recent years, and few are offered here, there must undoubtedly be numerous forms in Central and South America that are as yet undiscovered. This is an obvious conclusion when we consider how little is known of the United States and compare the still more unknown regions southward. As many of the South American species as were avilable for study have been included in the paper, since extensive collecting in Central America seems certain to extend the range of numerous species. In some cases the inclusion of South American forms has enabled the writer to better characterize certain groups. For example, the *scutellaris* group contains but four North American species, to which, however, may be added at least four South American forms.

Something over two thousand specimens have been gathered together for study. While a great deal of material has been studied from the Ohio State University collections, considerable has been obtained from other sources. The writer has met with a generous response from other workers with respect to the

loan of material. These are too numerous to more than mention, but he wishes to express his thanks to the following gentlemen: C. W. Johnson, C. H. Curran, C. L. Fluke, W. M. Davidson, A. L. Lovett, R. C. Shannon, F. R. Cole, F. E. Lutz, C. B. Garrett J. M. Aldrich. He especially desires to express his appreciation to Professors J. S. Hine and R. C. Osburn, for advice and assistance of many kinds, as well as the loan of considerable material.

Treatment of the Species.

The writer presents a scheme of division of this large and unwieldy genus into a number of groups. Although the arrangement is not perfect, most of the groups are quite clearly defined, and this would seem to considerably facilitate classification. Naturally a few species overlap, are intermediate, or fall into more than one group, but such cases are few. Moreover, the grouping arrangement is strengthened when considered in the light of geographical distribution. While the existence of certain groups has always been more or less tacitly assumed, and various terms applied to them, their value has not been sufficiently appreciated, nor the ease and readiness with which species fall into them. While a few structural characters exist, these are comparatively few, and the groups may not be thus distinguished; they are discussed below. Indeed the new world forms seem to present a remarkable dearth of structural characters, in strong contrast to several old-world groups, notably of Africa. Returning to the question of geographical distribution, we may take, for example, the *albifrons* group, a distinctly neotropical division, limited to the neotropical region, and the southernmost borders of the United States. On the other hand, such heavily pilose species as *pilosus*, *flavipes*, *bastardi*, etc., comprise a typically holartic group, with many palaeartic members. Doubtless more extensive collecting will add more European and Asiatic species to the American fauna. One such species is added in the present paper. Lastly, we have the species of the *aeneus* group, with spotted eyes, etc., with a single North American member, and a large number of Oriental and Aethiopian forms.

A number of genera or subgenera have been split off from the genus at times, but generally based upon rather slender grounds. Such are *Eristalomyia*, including the species with

arista bare to pubescent, and eyes unicolorous. The forms with eyes spotted have been subdivided into *Lathyrophthalmus*, with holoptic males, and *Eristalinus* with dichoptic males, etc. *Eristalis* sens. str., finally containing those forms with plumose arista. I have disregarded such separations in the present paper, for a number of reasons. Between plumose and pubescent (or bare) aristæ, there is a great deal of variation. However, it will be found that in the main, such characters do, *in part*, characterize the groups here presented. The members of the *dimidiatus* group have the arista typically plumose, whereas in *latifrons* the arista is bare; but the latter species is quite obviously a member of the group mentioned. Again in the "bare-arista" forms of the *albifrons* group, we have a markedly plumose species, *transversus*. The present *scutellaris* group will be found to be practically equivalent to *Doliosyrphus* of Williston, a division hardly warranting generic separation. In the present paper an effort has been made to shorten descriptions as much as possible, and all possible details have been included in the group descriptions. Moreover, a number of general structures of unessential value are not described, in order that those features of importance may be more carefully described. Hence such parts as the pleuræ, first abdominal segment, hypopygium, venter, etc., are seldom mentioned, and only when containing characters of importance. The present study would indicate that certain characters formerly used are of but little value, and likewise the reverse. The genus, or more exactly the groups, contain for the most part a number of very close species; few, in most of the groups, are separated by more than two or three characters. Group characters in general consist of size, form or shape of head and abdomen, pilosity of eyes, extent and length of pile, thickening of hind femora, nature of coloration and markings, etc. Specific characters embody a much larger assemblage, but are most largely drawn from the pile of the various body regions, and the markings of the abdomen, thorax and legs. Whereas in some species the degree of opaque markings of the abdomen makes good distinctions, in other species it seems entirely too variable. The same may be said of the abdominal pile. The scutellum rarely contains specific characters, but seems to in part characterize the groups. All the species of the *albifrons* group, known to me, have this structure opaque clear yellow.

Some seventy-one species are listed at the present time from North America. Twenty-three of these remain known only by the original descriptions. Of the forty-eight remaining forms, material has been obtained of forty-two, and the characters of the remaining six are well enough known to allow of their position being readily ascertained. An attempt has been made to place within their respective groups the remaining twenty-three species, and to indicate their apparent relationships. It is hardly possible to perfect completely a scheme of division within such a large group; the present study is offered however, in the hope of serving and facilitating the classification of a very interesting and, at the same time, as a whole, comparatively little known group of flies.

Key to the groups within the genus *Eristalis*.

1. Species with the thorax and abdomen thickly long pilose; feebly shining. *pilosus* group
   Species nearly bare or short pilose, wholly opaque or strongly shining........2
2. Thorax marked by very distinct fascia of black and lighter color; usually opaque. Generally to a large extent yellowish or reddish in color........3
   Thorax unicolorous, or at least with but very obscure fascia; usually shining. Forms seldom largely yellowish........5
3. Thorax longitudinally fasciate (eyes spotted, cf. *aeneus*)......*furcatus* group
   Thorax transversely fasciate........4
4. Hind femora considerably thickened; abdomen more elongate, *scutellaris* group
   Hind femora quite slender, or of not more than normal thickness; short, normally shaped species........*albifrons* group
5. Thorax dull, feebly shining........7
   Thorax polished, shining........6
6. Metallic species, eyes spotted........*aeneus* group
   Not metallic species, eyes not spotted........*dimidiatus* group
7. Hind tibiae arcuated and considerably flattened or compressed; larger species........*obsoletus* group
   Hind tibiae normal, usually smaller species........*arbustorum* group

The Pilosus Group.

Group description.

The members of the *pilosus* group are separated from several other groups, *dimidiatus*, *arbustorum*, *obsoletus* groups, by only two or three characters, but these seem fairly good ones. They present a quite characteristic appearance in being heavily long pilose species, usually but feebly shining. With respect to the former character, *occidentalis* may offhand, from some specimens, appear rather short pilose. A closer examination of species of the *dimidiatus* or *arbustorum* groups, will show that the species are not to be confused. Especially is the thickness

of the pile apparent about the face. The species *tenax* (*obsoletus* group) might possibly be confused in the pilosity of the head and thorax, but the abdomen of that species should be sufficient to separate the species with certainty, the abdominal pile of *tenax* being comparatively short. The abdomen, in the group, is usually much more shining than the thorax, and the former may be even somewhat metallic, as on the third and fourth segments of many specimens of *bastardi*, etc. The members of the *dimidiatus* group should not be confused with the present in this respect, as the thorax of the former are very definitely "shining," with the possible exception of *E. nemorum;* that species is markedly short pilose.

But little may be said of the *pilosus* group in a general descriptive way. Its members vary from medium size to quite large (for the genus). Several characters are highly variable; these being chiefly the infuscation of the wings, opaque areas of the abdomen, etc.

Antennæ dark in color, of the usual shape; the arista varies from bare to pubescent, to very short pilose basally, in such species as *occidentalis*, *bastardi*, *anthophorinus*, etc.; moreover, these three species are otherwise closely related. In *circe*, the antennæ are described as quite long plumose basally, for an *Eristalis*. Facial stripe prominent.

Thorax dull black, but little shining; heavily obscured with pile, the pile usually light in color. There seems to be a marked tendency towards the possession of obscure darker spots or vittæ upon the thoracic dorsum and moreover, this will in general be found true of the more opaque members of the whole genus. The species *nemorum*, together with the least shining members of the *arbustorum* and *obsoletus* groups, all show such vague and ill defined markings, which, however, should never be confused with the more definitely fasciate and vittate species as found in the *albifrons* and *furcatus* groups, etc.

The abdomen is somewhat more shining than the thorax; usually with light colored spots laterally, on the second and sometimes the third segments. The typical narrow, yellow cross bands, found so commonly on the posterior margins of the segments, in the *dimidiatus* group, are here almost entirely lacking, thus affording an additional difference between the groups. They are here present only in *occidentalis*.

Legs almost wholly dark in color; tarsi sometimes light. In most species the hind tibiæ are basally, sharply yellowish to

reddish, as is true of a large proportion of the genus; however it is not so constant here as in other groups, the species *occidentalis* and *pilosus* being often found wholly dark. Hind femora quite slender, to considerably, though not heavily, thickened, as in *flavipes*. Hind tibiæ normal, except in *flavipes*, where they are occasionally considerably arcuated and flattened.

Eyes wholly and heavily pilose, with the exception of a narrow strip on the lower occipital margin of the eye, more extensive and likewise less dense in the females. The members of the *dimidiatus* group have the pile usually confined to practically the anterior half of the eye, but the character can not be used to set the groups apart.

Wings never wholly hyaline (except sometimes in males of *flavipes*); usually with only a sharply defined, irregular brown band or line, running transversely across the middle of the wing, but often with this whole area heavily infuscated; in *flavipes* the whole basal two-thirds of the wing and especially the veins, may be brown.

Several European species are members of the group, as *intricarius*, *anthophorinus*, etc. The latter has been found to be the same as the species *montanus*, described by Williston.

Key to the species of the *pilosus* group.

1. Scutellum black...*persa* Will.
   Scutellum not black...2
2. Hind tarsi reddish...3
   Hind tarsi dark brown or black...4
3. Scutellum whitish, whitish pilose; anterior half of thoracic dorsum black pilose...*oestracea* Linn.
   Scutellum yellowish, yellow pilose; anterior half of thoracic dorsum yellow pilose...*flavipes* Walk.
4. Thorax yellowish red in color...*circe* Will.
   Thorax brown or black...5
5. Abdomen broadly yellowish to reddish on the sides, leaving a median black stripe, that is opaque on the anterior half...6
   Abdomen not broadly yellow along the sides...7
6. Posterior margins of abdominal segments never with narrow yellow bands, *anthophorinus* Fallen
   Posterior margins of segments always with narrow yellow bands, *occidentalis* Will.
7. Third segment with an opaque crossband posteriorly...8
   Third segment with two opaque circular spots near the middle..*pilosus* Lw.
8. Abdominal pile, largely, or in part black; abdomen never with yellow posterior marginal bands on the segments...9
   Abdominal pile wholly yellow; yellow marginal bands present on the segments...*occidentalis* Will.
9. Larger species. Yellow spots of abdomen paler, thorax unicolorous in appearance, posterior opaque band of third segment quite narrow or wanting...*mellisoids* n. sp.
   Smaller. Spots of abdominal segment often reddish; thorax with the appearance of being much blacker on the disc. Posterior opaque band of third segment usually decidedly wider...*bastardi* Macq.

Eristalis occidentalis Williston.

Male and *Female.* Antennæ black; arista very short pubescent. Ground color of face, cheeks and prominent facial stripe, shining black. Color of face obscured beneath dense yellow pollen; likewise clothed with long, thick, yellow hair; pile of front and vertex, abundant, yellow. Thorax dark brownish black, feebly shining, the females not differing from the males in this respect, as they do in the *dimidiatus* group. Clothed with abundant yellow pile. The obscure vittæ of the thorax, found in several members of the group, are more than usually prominent in *occidentalis.* There are two such vittæ, lighter in color than the rest of the thoracic dorsum, with sometimes a third in between. They are never strongly marked anteriorly and are occasionally with difficulty made out. The ease or difficulty, with which obscure vittæ may be seen in any group, depends largely on such factors as dust, dirt, grease, etc. Scutellum brownish yellow, moderately shining, pile yellow. Abdomen brownish to slightly greenish black; in a rather large degree, quite shining. The males differ from the females in being much more shining, and highly brassy or æneous, on the third and fourth segments. Both males and females seem characteristic in having narrow yellowish to reddish, posterior marginal bands on the second, third and fourth segments. The spots of the female, are confined to the second segment. In the male, they extend more or less broadly on to the third segment likewise; in both sexes they are quite often tinged with brownish or reddish, but never markedly reddish. Pile of abdomen in both sexes wholly yellow. Legs of the group type; hind femora slender; pale basal area of tibiæ rarely wanting, usually prominent. Wings always infuscated to some extent in the middle of the anterior half, the infuscation usually slighter in extent, and more sharply delimited from the basal area of the wing, than is found in its near ally, *bastardi.*

Length of the species, 10 to 12 mm. Material studied is from Washington and British Columbia.

This species is one of several, comprising the *occidentalis* complex, the species of which are certainly troublesome to separate, owing to considerable intra-specific variation and to the complexity added here, as in other groups, by various European species. The species *occidentalis*, *bastardi*, *mellissoides* and *anthophorinus* form a group that are closely allied and a discussion of the situation, that may serve to show their relationships, is included under this species. The characters of face and legs, in these four species, are so similar that there is naught to be found to separate them, leaving only the pile and the markings of the thorax and abdomen to distinguish them. However, the study of a good series shows these characters to be comparatively trustworthy.

Occidentalis has been separated from *bastardi* formerly, by the wider, opaque, posterior band of the third segment of the latter, together with the presence of a median opaque spot, sometimes present, on the fourth segment of the former. The question of the median spot of these segments has been taken up in more detail in the *dimidiatus* group. While most *occidentalis* show the spot rather prominently, and most *bastardi* have the segment wholly shining, many of the latter show traces of such a spot. For this reason little emphasis has here been laid on the presence or absence of the spot. The species *bastardi* is considered in this paper to be definitely characterized by the presence of extensive black pile on the abdomen, both anteriorly as well as posteriorly, the fourth segment, it is true, being usually yellow pilose, as well as the yellow spot of the second segment. Further, the fourth segment is usually wholly shining, the posterior, opaque margin of the third segment, usually rather wide; the spots of the second segment more obscure. In five males only, out of a considerable series, do I find very small yellowish spots on the anterior corners of the third segment; they are always much more prominent in the males of *occidentalis*. A number of specimens have come to me for study, in series of *bastardi*, that have the abdomen wholly yellow pilose; these forms seem to differ in still other ways, and I consider them to be wholly different from either of the two species just mentioned. I have placed them in the European species *anthophorinus*, discussed below. Thus characterized by its extensive black pile, *bastardi* may only be confused with *mellissoides*. The median spot of the fourth abdominal segment, the narrow or wanting, posterior opaque bands of the latter, on the third segment, together with the but slightly vittate thorax, should separate them. The specimens of *mellissoides* are certainly larger than any *bastardi* I have ever seen. Lastly, the infuscation of the wings in the latter is usually greater in extent, and more diffused than in that species.

Among a series of specimens of *occidentalis*, I find several males and females that do not agree. They are undeniably close to that species, but the differences are such that I believe one is warranted in considering them as a distinct species, and I have so considered them here. I have called it *mellissoides*, and although described in more detail further along, it is likewise compared with *occidentalis*. The female of the latter

contrasted with the other, shows the spots of the second segment to be more shining, more reddish, and the pile of the abdomen wholly yellow. The pile of *occidentalis*, further, seems to be slightly shorter and has the appearance, off hand, of being depressed somewhat. The narrow yellow posterior bands of the segments, in that species, are lacking in *mellissoides*. The thoracic vittae are much less prominent, and the four specimens of the latter are considerably larger. The species has the pile of the second abdominal segment posteriorly, the third segment, and in one specimen, the fourth segment, wholly black; the pile seems a trifle longer, more erect and abundant; the spots of the second segment, while distinct, are less shining.

The males of the species differ perhaps more markedly yet. *Occidentalis* has the yellow spots of the second and third segments, broadly confluent; the spots of *mellissoides* are separated narrowly, by black posterior bands and the spots themselves are less prominent. The pile of the former is wholly yellow; of the latter yellow, with transverse black bands on the second and third segments, and there are no yellow margins on the segments posteriorly.

Eristalis mellissoides n. sp.

Female. Facial stripe and cheeks black. Antennæ black; arista short plumose basally, its hairs perhaps a trifle shorter than in *occidentalis*. Ground color of face, light, loose, yellow. Pile of front, save just before the ocelli, vertex and occiput, long, light yellow. Thorax dark greenish brown or black, obscured by dense, long, yellow pile; vittæ usually very much obscured; faintly shining. Scutellum, yellow, more shining; subtranslucent; pile yellow. Whole of pleural pile yellow. Abdomen black; second segment with a light yellow spot on either side, separated by black, the width of the black median band, one-third or more of the width of the segment. Spots of second segment shining, and the black likewise, narrowly, immediately behind the spots. Third segment shining, an uninterrupted, opaque black band, often quite narrow, on both anterior and posterior margins, the anterior band frequently with a median prolongation posteriorly. Fourth segment wholly shining, save for a median triangular spot on the anterior margin, directed posteriorly. Pile of abdomen abundant; on first segment wholly yellow, sometimes the posterior half black; third segment wholly black; fourth and following segments usually yellow, sometimes narrowly black, anteriorly. Legs black, black pilose; the basal half of hind tibiæ, basal third of front and middle tibiæ, pale yellowish to brownish white, white pilose; short, stiff pile of tarsi brownish. Wings infuscated in the middle and anteriorly, the marking

more sharply delimited, and less extensive than in *occidentalis*, *bastardi*, etc.

Male. Similar to the female. Yellow spots on both second and third abdominal segments, the latter the smaller; the black abdominal pile is in the form of transverse bands on the posterior margin of the second and third segments. Fourth segment as in *occidentalis*, shining metallic, a minute, median triangle, anteriorly.

This form is, as shown above, close to *occidentalis*. However, it seems certainly distinct, in the large size, largely black pilose abdomen, and total lack of yellow margins on the segments, albeit, these are often obscure in the latter species. Length, 10 to 14 mm.

Five males and six females. Type male, allotype female, and six paratypes, from Dr. R. C. Osburn's collection, from the following localities: Victoria, B. C., July 4, 09; April 10, 09; Vancouver, B. C., April 27, 07; Port Renfrew, B. C., August 16, 01; Gabriola Is., B. C., May 8, 08. Three paratypes in Professor A. L. Lovett's collection, Corvallis, Oregon, June 3, 99.

Eristalis bastardi Macq.

A detailed description has not been thought necessary, as a careful comparison with the species has been given. Williston recorded it from New England, Canada and Labrador. I have studied specimens from New Jersey and Ohio. Apparently an eastern species.

Eristalis anthophorinus Fallen.

E. montanus Will. Proc. Amer. Phil. Soc. xx, 322.

A number of specimens from both eastern and western United States, (North Dakota, Alaska, New York, New Jersey), have been separated by the writer, from collections loaned for study, mostly passing under the name *bastardi* or *occidentalis*. They surely belong to the European species, *anthophorinus*, and I have compared them with European material. From *bastardi* they should at once be separated by the wholly yellow pilose abdomen. Only one character remains to distinguish the species from *occidentalis*, this being the presence of yellow marginal bands on the segments of the latter, posteriorly. *Occidentalis* was described from only six specimens, but this is one of the characters included in the original description. These bands seem altogether too prominent in most specimens of that

species, and too plainly lacking in the other, to consider them as otherwise than distinct. Moreover, *anthophorinus* has the thorax never so prominently vittate, as in the other species. Superficially, it the more resembles that species, in that the third and fourth segments of the males, in both, are aeneus.

Close as the species approaches *occidentalis*, it is even nearer to *montanus* Will. The latter was described from a single specimen. Some sixty or seventy specimens, of what is evidently Williston's *montanus*, have been collected and so determined, by Prof. J. S. Hine, in Alaska. This series enables us to understand that species much more completely. There is no doubt in the mind of the writer but that the two species are synonyms. About thirty specimens of the above mentioned series may be distinguished by having the black median stripe of the abdomen, decidedly black pilose; *anthophorinus*, on the other hand, is described by European authorities as wholly yellow pilose on the abdomen, and in this, my specimens from the United States agree. However, some of the Alaskan specimens are likewise wholly yellow pilose; about half a dozen specimens show traces of black pile on the mid-dorsum of the abdomen. All my European specimens, as well as the ones from the United States, show the spots of the abdomen reddish yellow. In the whole Alaskan series they are decidedly red, with little or no yellow. All of these specimens are rather large in size as compared with the others and the black is a trifle more extensive, perhaps. The type of *montanus*, itself, is described as wholly yellow pilose on the abdomen. Whether the black pilose forms, from Alaska, is separable or not, must await the study of more European material. At any event, it could not be *montanus*. The type of this species was from Wyoming.

This species is described by Lundbeck as always with yellow to a greater or less extent on the sides of the abdomen, on the third segment and usually the fourth, likewise.

Male and *Female*. Antennæ brownish black; arista very short plumose to microscopically pubescent basally. Facial stripe and cheeks shining black. Face light in color; pile abundant, but loose, of medium length, yellow. Pile of eyes thick; black. Thorax dark greenish or brownish black, obscured by thick yellow pile; vittæ nearly wanting, very indistinct. Scutellum yellow to brownish, subtranslucent; pile yellow. Abdomen reddish yellow; a broad black median stripe, slightly extended towards the sides posteriorly, on the margins of segments two, three and four, sometimes almost reaching the lateral margin, and

likewise slightly extended to the sides anteriorly, widely dilated on the second segment. First segment wholly black. Pile of abdomen of medium length, wholly yellow, slightly blackish in the middle of one specimen from New York. Legs black; apices of femora very narrowly, basal third or fourth of front and middle tibiæ, and basal half of hind tibiæ, yellowish. Length, 10–12 mm.

Four specimens are rather peculiar in appearance, due to the absence of light spots on the third and fourth segments, except very slightly in two of them, in the anterior corners of the third. As mentioned above, they may be called var. *perplexus*, n. var.

Holotype male and three paratypes, males, in the coll. of Dr. R. C. Osburn.

Description taken from both European and American specimens. I have a dozen or more of the latter, at hand, from the following localities: Vernon, B. C., Sept., 02; Port Renfrew, B. C., Aug. 16, 01; Regina, June 18, 07; Banff, Alta., Paterson, N. J.; White Plains, N. Y.; Aqueduct, N. Y.; Caledonia, N. D. (Dr. R. C. Osburn's collection).

The species has been discussed above. The males are very much like the males of *occidentalis*, but the females of the two species markedly differ from one another.

Eristalis pilosus Loew.

Male and *Female*. Antennæ black, arista bare to microscopically pubescent. Facial stripe and cheeks shining black. Ground color of face black. Pile of face, front and vertex, loose, sparse, and pale yellowish white. Thorax dark greenish black, but slightly shining. Scutellum yellowish brown, subtranslucent. Pile of thorax and scutellum, pale yellowish white, with something of a greenish tinge. Abdomen black, light greenish to brownish yellow spots on either side of the second segment, shining, separated from the posterior margins by a band of black. Abdomen shining, on the second segment anteriorly, on the third segment, two characteristic, oval spots in the middle, opaque. Pile of second segment except a narrow posterior band, and fourth segment, wholly yellow; otherwise black. The black and yellow pile is rather sharply delimited, giving the abdomen a decided banded appearance. Legs black, base of tibiæ sometimes very narrowly light brownish to yellowish, usually black. Hind femora quite slender. Wings usually wholly hyaline, occasionally with a slight infuscation in the middle. Length, 11–13 mm.

At once the least known and best distinguished species of the group. Some twenty specimens were collected and so identified, by Professor J. S. Hine, from Savonoski, Alaska,

July, 1919. A specimen from Hopedale, Labrador, has been loaned by Mr. C. H. Curran. Easily separated from the other species of the group by the slender femora, characteristic band-like pile of the abdomen, circular opaque spots of the third segments, etc. The wings are more hyaline, the arista bare, the color of the pile somewhat peculiar, etc.

Eristalis flavipes Walker.

Antennæ dark brown; arista decidedly plumose on the basal half. Face, cheeks and facial stripe, shining black. Pile of face, front and vertex, sparse, long, yellow. Thorax black, feebly shining, obscured by very dense, long, yellow pile, less abundant in the middle or disc of the thorax, and thus allowing the ground color to show as a centralized black spot; pile of disc of thorax often interspersed with black. Abdomen black, largely shining. Pile of second segment basally, and of fourth segment, slightly yellow; remaining segments black pilose. Legs black, black pilose; hind tarsi characteristically reddish orange, pile similarly colored. Front and middle tarsi sometimes likewise reddish. Wings always more or less heavily infuscated in the females; always practically hyaline in the males. Some thirty typical specimens, from both Atlantic and Pacific states. Length, 13–17 mm.

Various specimens depart from the above description, to form well marked varieties, and in fact, the species is one of the most variable of Syrphids; within the genus, only *E. intracarius* of Europe, rivals it in degree of variation.

The first of these may be characterized by the more extensive black pile in the female, on the disc of the thorax. The abdomen is wholly yellow pilose. This seems to be Loew's variety *melanostomus*. Three females only. Massachusetts, New Jersey and New York.

A second form differs from the typical specimens in having the abdomen broadly reddish pilose on the second and third segments. The black of the thoracic disc is in the form of a sharply marked transverse band, usually reaching to the base of the wings. Nine specimens, both males and females, Alaska, Idaho, Oregon and Wisconsin. There seems to be a marked tendency to assume a reddish coloration in pile of more northerly distributed forms. *Volucella bombylans*, likewise, exhibits such a color phase. The form may be known as variety *rufipilis*, n. var.

Holotype male and allotype female in the collection of writer; paratypes in O. S. U. collection and of Dr. R. C. Osburn.

A notable character of *flavipes* is the marked difference in size and appearance of males and females. The males are considerably the smaller, though an occasional specimen will reach the size of a small female. The yellow pile of the typical male is sharply marked and band-like. This species is not to be confused with any other, the red hind femora, wholly black abdomen, large size, etc., distinguishing it.

Eristalis oestraceus Linne.

Male and *Female.* Antennæ dark brown; arista short plumose basally. Face, facial stripe and cheeks shining black. Pile of face, front and vertex, almost white, rarely yellowish on the front. Pile of eyes black. Thorax black, feebly shining; pile of anterior two-thirds and pleuræ, abundant, deep black; pile of remainder of thorax and scutellum, white. Scutellum peculairly whitish, faintly shining. Abdomen black; opaque, save for the anterior corners of second segment, a transverse band in the middle of the third, nearly the whole of the fourth, shining. Pile of abdomen basally, similarly to scutellar pile; on the second segment posteriorly, and the whole of the third, black. The pile of the fourth segment, forms a sharply marked transverse band, reddish yellow or orange in color. Legs black, black pilose; hind tarsi, and front and middle tarsi less sharply, reddish yellow, reddish pilose. Length, 11–15 mm. (From European Material).

A striking, easily distinguished species. First recorded by Walker, from the Hudson Bay country, as *Eristalis* (*Syrphus*) *oestriformis* Walk. Austen has, as pointed out by Dr. R. C. Osburn, (J. N. Y. S. S. vol. XXIII, p. 144), shown *oestriformis* to be a synonym of *oestracea L.* There is no reason why the species should not occur in this country. Walker's type is in the British Museum.

Eristalis persa Williston.

This species quite evidently belongs in this group. No specimens have been studied, but Williston's description does not leave its relationships in doubt. The salient features of the species are given below. Face shining black, long yellowish white pilose. Antennæ reddish yellow. Thorax and scutellum black, the latter shining, the former more opaque. Pile of thorax entirely light yellow, posteriorly and on the scutellum, black. Abdomen black, black pilose; largely shining. Legs black, tips of femora, hind tibiæ, whole of four anterior tibiæ, and all the tarsi, light yellow; hind femora slender.

Female. Length, 12–13 mm. Guerrero, Mexico.

Eristalis circe Williston.

No specimens of this species have been seen. The description and figure by Williston leave no doubt as to its position. The thorax is dark ochraceous, the scutellum and abdomen, with the exception of a black spot medianly on the anterior margins at second and third segments, light yellowish red. Pile of thorax and abdomen, similarly colored. Face shining black, yellowish on the sides; pile yellow. Third antennal joint reddish; arista quite plumose. Legs, black; four anterior tibiæ, for the larger basal part, the base of the hind femora, and the base of the four anterior tarsi, more or less, yellow. Male. The female differs from the male in having the abdomen black, black pilose, except in the middle of the second segment, where it is similar to the pile in the male. The hind femora of the male are described as moderately thickened; of the female as not thickened.

Length, 12–13 mm. Guerrero, Jalapa, Oaxaca, Mexico.

The Furcatus Group.

Group description

Species of small size; very short pilose. Face of the usual type in profile; prominence rather less than average. Third joint of antennæ very little longer than broad; arista bare. Eyes heavily pilose, almost confined to the anterior half, heaviest above. Facial stripe well developed; face heavily covered with pruinescence; normal in shape. Thorax opaque, strongly marked with longitudinal bands or fascia; sometimes broken up into spots; usually interrupted at the suture. Scutellum variable. Abdomen usually considerably marked by yellow; largely opaque; of the normal shape. Hind femora varying from considerably thickened to slender; hind tibiæ slender, sometimes considerably arcuated, never flattened. Wings hyaline.

Key to species of the *furcatus* group.

1. Stripes of the thorax very much obscured and feebly indicated.............2
   Stripes quite distinct and prominent.............4
2. Cheeks black.............*phillipii* Schiner
   Cheeks reddish.............3
3. Third and fourth abdominal segments reddish; brown anterior border of second segment obsolescent.............*ornatus* Town.
   Third and fourth segments blackish; brown anterior border of second segment not obsolescent.............*ochraceous* Will.

4. Stripes of mesonotum limited to posterior half; broken up into spots, *trigonus* Will.
Stripes run nearly the full length of the thorax 5
5. Scutellum yellow, opaque .... *Texanus* n. sp.
Scutellum black or brown 6
6. Scutellum wholly shining, dark brown or black, sometimes metallic, *furcatus* Wd.
Scutellum pale brown medianly, shining, never metallic; velvety black on either side .... *quadraticornis* Macq.

Eristalis phillipi Schiner.

(Plate II, Figs. 13, 16).

Male. Antennæ reddish brown. Face densely covered with pale yellowish pollen; pile of the same color. Facial stripe, shining light yellowish brown. Cheeks black. Markings of thorax quite variable. Before the suture are four dark brown stripes, the inner two sometimes blackish.. The two "inner," dark colored stripes, continuous behind the suture, recurved posteriorly on the outer side into a large oval, black spot, the latter sometimes pale centrally, thus appearing horseshoe shaped. Before the suture, the spaces between the above mentioned stripes, are narrower, of a lighter brown color and more or less continuous past the suture. Narrow, whitish, sutural line, conspicuous. Pile of thorax slightly brownish yellow. Scutellum wholly opaque, clear yellow; pile rather long. Second segment of abdomen clear yellow, with a wide black median stripe, deeply concave on either side. Third segment of the same color, with a similar median band, of nearly the same width, somewhat dilated posteriorly; the yellow sometimes obscurely dark brown. Fourth segment opaque black, with a transverse metallic band, narrowly interrupted medianly. Femora, except the narrow apices, black. Hind femora slender. Hind tibiæ dark reddish brown, sometimes black in the middle. Front and middle tibiæ pale yellowish; sometimes dark brown on the third. Wings wholly hyaline.

Female. Differs from the male as follows: Stripes of thorax before the suture, rather indistinct; "inner" black stripes replaced by a pair of nearly round black spots. Large "outer" spots, behind the suture, broken on the posterior side, resembling an interrogation mark, the posterior ends connected by a median transverse band. Median stripe of a second segment wider, dilated posteriorly, continuous with a narrow posterior marginal band. Third segment wholly black, or with a very small yellow spot in the center on each side. Length, 9–12 mm.

Six specimens. Colima, Valparaiso, Quillota, Chile; Buenos Aires, Argentina.

Eristalis ornatus Town.

No specimens of the species have been seen. The color of the cheeks is not mentioned, but the species is described as resembling *ochraceus* Will. The chief features as described are: Pile of frontal triangle yellow, intermixed with black. Second,

third and fourth abdominal segments reddish yellow; linear brown stripe of second and third segment obsolescent. Legs deep reddish yellow; proximal half of middle and front tibiæ yellowish white. Hind femora narrowly and faintly brownish distally, above. Tarsi wholly reddish yellow. Wings hyaline, a small, well defined, quadrate, blackish spot at end of auxilliary vein, between the latter and the first vein. Two males. San Rafael, Lower Calif., July. C. H. T. Townsend. The thorax is not described, except as "resembling *ochraceus*." Length, 10–11 mm.

Eristalis ochraceus Will.

One poorly preserved male, from Bartica, British Guiana, may belong here, although there are several discrepancies. The thorax shows four blackish stripes, but the ground color is gray, not ochraceus yellow. Scutellum brownish basally, clear yellow on the outer half; wholly opaque. The third abdominal segment is the same color as the second, with a small round median spot, not black, with reddish lateral spots; it shows in addition, a marked flattening, obliquely, from a side view, of the front, that is not mentioned by Williston; moreover, the ocelli are raised on a small, but conspicuous prominence. Facets of the eyes distinctly enlarged. Quite possibly it is distinct. Length, 10 mm.

The characters as given by Williston are briefly as follows: Face yellow; thickly light yellow pollinose; cheeks shining red. Eyes slightly pilose; facets on upper half distinctly enlarged. Mesonotum, densely opaque, ochraceus yellow, with similarly colored pile; four to six slender stripes, feebly indicated. Scutellum opaque reddish yellow. Second segment of the abdomen, the color of the scutellum, with a slender blackish brown anterior margin, a linear brown stripe, and a narrow, posterior, blackish brown band in front of the yellow hind margin. Third segment blackish, with a red lateral spot and hind margin, and a narrow, entire, shining median band. Legs red, base of tibiæ and tarsi, except tips, yellow; distal part of hind femora and a ring on hind tibiæ, blackish, etc. Wings hyaline. Length, 12 mm.

Chapada, Brazil. One male. Williston.

Eristalis trigonus Will.

Not seen; the description, however, leaves no doubt as to its position. The characters are briefly given below.

Male. Face amber colored, densely yellowish pollinose, yellow pilose; facial stripe shining. Cheeks black. Antennæ yellowish red. Eyes densely pilose. Thorax before the suture, opaque brownish gray; behind the suture with three large, opaque, velvety black spots, the median one elongate oval, the lateral ones forming a right angled triangle, with the hypothenuse slightly concave. Pile yellowish brown. Scutellum opaque reddish brown, more blackish at the base. Second segment of abdomen yellow, with a wide median black stripe, either side concave, and somewhat narrowly dilated along the posterior margin. Third segment with a median, opaque black stripe and a narrow, brown or blackish posterior band. Fourth segment reddish or brown, with a narrow, shining black crossband. Legs: femora, except the tip, tip of four anterior tarsi and hind tarsi black, elsewhere red; hind femora thickened. Wings hyaline.

Female. Front with an opaque black band below ocelli; pile black. Abdomen shining black; second, third and fourth segments each with a narrow yellow hind margin and a posterior, opaque black band; second segment with an anterior band, connected broadly in the middle with the posterior one; third segment with an anterior oval spot, opaque black. Length, 9–11 mm. Guerrero, Mexico.

A striking species.

Eristalis texanus sp. n.

(Plate II, Fig. 21).

Female. First two joints of antennæ black, third joint dark brown. Facial stripe and cheeks shining black. Face covered with very dense whitish pollen, extending halfway up the front, becoming darker at the vertex, and pile of the same color. Ground color of the thorax, opaque ashy gray, marked with black as follows: Four stripes, the outer pair, slightly wider, and interrupted by a short space at the suture, thus forming two spots on either side, the posterior one of which is more or less triangular; inner stripe continuous past the suture, uninterrupted. Pile pale yellow. Scutellum clear yellow, wholly opaque. Second segment of abdomen opaque black, with a not very large, slightly brownish, deep yellow spot on each side, somewhat roughly triangular, the pointed ends directed inward; widely separated by black medianly; posterior marginal border of segment, black. Segments three, four and five, each shining metallic black or brassy, narrowly interrupted medianly, with a narrow, opaque black marginal band. Femora shining black, narrowly yellow at the apices. Basal third of front and middle tibiæ, becoming reddish medianly and black on the apical portion. Larger, basal portion of first joint of middle tarsi, yellowish; remaining

tarsi black. Hind femora considerably thickened; hind tibiæ slightly flattened. Wings hyaline. Length, 9.5 mm.

Type female: Coyote Lake, Bailey, Co., Texas, August 24, 1921. Collection of F. R. Cole.

Eristalis furcatus Wied.

(Plate II, Figs. 11, 20).

Male. Antennæ light reddish brown. Facial stripe and cheeks shining black. Face covered with pale yellow pruinescence, and pile of the same color. Pile of front and vertex blackish; of eyes yellowish. Facial knob rather prominent. Thorax opaque gray before the suture, becoming slightly shining, with a steel blue cast, behind; marked with black as follows: Four opaque black stripes, the inner two narrowly separated, continuous and confluent a short distance behind the suture, thence extending as one, resembling a two-pronged fork. Outer pair slightly wider, tapering from either end somewhat, and interrupted at the suture. Scutellum dark brownish, highly shining metallic, more lutescent on the rim. Second segment of abdomen black, feebly shining, a not especially large, subround spot on either side, brownish yellow, variable in size. Third segment black, with similar, but slightly smaller and a narrow, metallic cross band, slightly interrupted medianly; an opaque black margin posteriorly. Fourth segment opaque black, a metallic cross band, narrowly interrupted medianly. Hind femora considerably thickened, black, brown apically. Front and middle femora, dark brownish black. Front and middle tibiæ and tarsi, and hind tarsi, dark brown; hind tibiæ reddish brown. Wings hyaline.

Female. Similar; upper half of vertex blackish; bare calloused spot above antennæ, light shining brown, surmounted by a rounded, shining black spot. Abdomen wholly shining, slightly metallic black; light spots obsolete; yellow posterior marginal bands obsolescent. Length, 10 mm.

About twenty-five specimens, from Corumba, Sao Paulo, Rio de Janeiro Brazil; Guerrero, Mexico; Amatitlan, Guatemala. Also is recorded from Colombia, Montevideo and the Argentine Republic.

Eristalis quadraticornis Macq.

(Plate II, Figs. 12, 18, 22).

Male. Antennæ black; third joint short, sub-quadrate, with a slight obliquely truncate appearance; arista shorter than usual and somewhat thickened basally. Facial stripe and cheeks shining black. Face somewhat deeply and acutely produced. Eyes densely and rather long pilose for an *Eristalis*. Face pale yellowish pruinose; pile of the same color. Pile of front black; of vertex, pale whitish yellow. Thorax, opaque dark grayish brown, with complicated markings of opaque black and pale grayish brown as follows: The pale markings in the

form of a narrow median line, slightly widening posteriorly and continuous with on either side, a roughly R-shaped figure, the latter turned outward, and extending nearly the whole length of the thorax. The upper (anterior) closed circle of the R, is dark brown in the middle, and sometimes lined with a dark band or ring; the posterior, open circle, is lined with an opaque black band. Scutellum shining, grayish brown in the middle, opaque black on either side. Abdomen opaque velvet black, with lighter markings as follows: Second segment with a pale brownish yellow or orange spot on either side, extending more narrowly, the full length of the third segment also, on the second segment sending a small, rounded lobe medianly; hence leaving a wide, deeply concave, black median band; yellow spots extending along the side margins. Median black band of third segment, wider, lateral margins also black. The fourth segment wholly black, a shining cross band, narrowly interrupted. All the femora shining black, narrowly yellowish apically; hind femora somewhat thickened. Tibiæ dark brown, yellowish basally. Tarsi dark brown. Wings hyaline.

Female. Similar; front, with a small round, opaque black spot, on either side, just in front of the ocelli, touching the eyes. Light spots of abdomen usually obsolete, when present, confined to the second segment; similar to the male, darker.

Length, 8–9 mm. Six specimens. Santiago, Chile.

THE ALBIFRONS GROUP.

Group description.

The species of this group all exhibit an unusual amount of yellowish, sometimes reddish color, marked by black. All of medium size with the exception of *minutalis*. Third joint of antennæ rounded, a trifle longer than broad; arista, except in *transversus*, bare to microscopically pubescent, thickened basally. Face light to dark in color, but in every case obscured by dense, appressed, light colored pile. Occiput covered with similar pile; that of front and vertex longer and more erect, sometimes dark in color. Cheeks and a median facial stripe from just below the antennæ to epistoma, bare, shining. Dorsum of thorax velvet black in color, marked by from one to two ashy or cinereus bands, a band being just before the suture, the pre-sutural band, and the other behind the suture and just in front of the scutellum, the post-sutural or prescutellar band. In addition the area just between and below the humeri is sometimes ashy in color, forming a third band, but is not considered here. Pleuræ likewise ashy gray, covered with fairly long, sparse pile. Scutellum opaque yellow, sub-translucent. Pile

of thoracic dorsum abundant but quite short, light in color though generally dark on the black areas. First abdominal segment yellow or black. The second yellow to red, marked by a median black line or triangle, its base on the posterior border and sometimes extending to the lateral margins, its apex usually reaching the anterior margin. Third segment with a spot in the anterior corners, yellowish, interrupted medianly by a black band that usually extends to the sides posteriorly, but is often attenuated or broken in the middle, leaving the anterior half a small round black spot. Fourth segment with similar though smaller yellow spots in the anterior corners, very often wholly black.

Hypopygium shining black. Pile of abdomen short, sparse, light in color, dark on the black areas, longer posteriorly. Segments two, three, and four with the characteristic, narrow, yellow posterior marginal bands found in so many species of *Eristalis*. The abdomen is typically opaque with a small, shining to metallic, often interrupted band on the fourth segment, and occasionally a similar though smaller area on the third segment.

Legs: Femora and a part of tibiæ generally shining black; knees and tarsi usually light in color. Hind femora slender, only very slightly thickened in one or two species. Wings hyaline, rarely with an infuscated area near the stigma.

The principal characters that have been used in this group, as will be seen from a study of the accompanying keys and descriptions, are the arrangement of the thoracic bands together with the configuration and extent of the black markings of the abdomen, particularly of the second segment. The group may readily be divided up on the basis of one or two ashy bands on the thorax, or of the number of black bands. Two species seem to have the ashy color of the thorax a pure gray in contrast to the brownish tinged bands of the remaining species. On the abdomen several species seem quite characteristic in having the median black band, rather wide, and unattenuated posteriorly; in the others it is usually triangular. Three species have the hind femora to a slight degree more thickened than the remaining members.

A considerable series of specimens seems to demonstrate the decided value of the characters mentioned above. Some slight

variations occur, but these do not seem greater than are to be expected. They consist largely in the amount of yellow or black coloration or pigment of the abdomen, color of the legs, etc.

Several species have been considered with this group that do not properly belong there. These are *vinetorum* Fabr., *transversus* Wied., *hortorum* Fabr., and *minutalis* Will. Of these forms the first differs markedly in being of a pronounced rusty or reddish brown color over the entire insect. All but *transversus* differ further, in having the hind femora considerably though not heavily thickened. In all but *minutalis* the lighter bands of the thorax are not of the characteristic ashy gray or cinereus color found in the *albifrons* group. In *hortorum* they are deeply yellow and the whole insect is strongly reddish and yellowish in color with the exception of the black abdominal markings. In this species there is a dark transverse band on the apical half of the wing; it and *transversus* resemble one another in that the entire third abdominal segment in the female is black with the exception of the narrow shining posterior margins common to nearly the whole genus. It will be seen that *vinetorum* resembles *obsoleta* and *aemula* very strongly in coloration. Moreover as *aemula* is one of the less elongate members of its group, the resemblance is heightened. Thus *vinetorum* occupies a more or less intermediate position between the three groups. The species *minutalis*, however, is quite like a very diminutive member of the *albifrons* group. It differs in the more thickened hind femora and the scutellum is not entirely yellow. The matter of the misfit of species in the groups is discussed in more detail in this group, since there are more of such cases.

By far the majority of the North American forms seem to fit quite well in the several groups and these are marked by only one or two prominent, though striking, characters together with others less so. The number of mis-fits is small and it must be kept in mind that a perfect arrangement is hardly possible.

Key to the species of the *albifrons* group.

1. Scutellum decidedly reddish brown in color; hind femora considerably thickened........2
   Scutellum clear yellow to tinged with reddish; hind femora comparatively slender........3

2. Wings with a wide black band on the apical half; pile of front golden yellow.. *hortorum* Fabr.
   Wings nearly hyaline; pile of face never golden yellow....... *vinetorum* Fabr.
3. Bands of thorax rather shining, the gray somewhat metallic; legs usually in large part yellow (female never with yellow on the anterior half of third abdominal segment)........................ *transversus* Wied.
   Whole thorax decidedly opaque, never metallic; legs always in considerable part black (female always with yellow markings in the anterior corners of third segment).................................... 4
4. Very small in size, five to seven mm.; scutellum blackish basally, *minutalis* Will.
   Larger, seven to twelve mm.; scutellum wholly yellow.................. 5
5. Two ashy bands on the thorax, a sutural band and a prescutellar band..... 12
   Only one ashy band on the thorax, a sutural band....................... 6
6. Markings of the second abdominal segment attenuated towards the anterior part.. 8
   Markings reach the anterior margin of the second abdominal segment in nearly or completely their full width................................ 7
7. Medium black markings of second abdominal segment less than twice as long as wide.. *fasciatus* Wied.
   Median black markings much slenderer (in part)............. *atrimanus* Lw.
8. Only one black band on dorsum of thorax.................. *pusillus* Macq.
   Two black bands on the dorsum of the thorax.......................... 9
9. Presutural ashy band interrupted medianly............. *triangularis* G. Tos.
   Presutural ashy band entire.. 10
10. Black of posterior part of second abdominal segment never extending to lateral margin (male and female)....................... *floreus* n. sp.
    Black of the posterior part extends to the lateral margin................ 11
11. Posterior band reaches the lateral margin widely, reddish species, not pronouncedly blackish................................... *atrimanus* Lw.
    Posterior band reaches the sides very narrowly; light color of abdomen and scutellum clear yellow; more strongly blackish in color (female, rarely,)... *floreus* n. sp.
12. Markings of the second abdominal segment attenuated towards the anterior part.. 15
    Markings reach the margin of the first abdominal segment in nearly or completely their full width.. 13
13. Only one black band on the dorsum of the thorax........... *alhambra* n. sp.
    Two black bands on the dorsum of the thorax.......................... 14
14. Median black markings of the second abdominal segment less than twice as long as wide (male, female in part).................. *cubensis* Macq.
    Markings three to five times as long as wide............... *albifrons* Wied.
15. No prescutellar ashy band.................................. *taenia* Wied.
    A prescutellar ashy band on dorsum of thorax.......................... 16
16. The black is only half as wide as the length of the scutellum; hypopygium normal in size (female).............................. *cubensis* Macq.
    The band nearly or fully as wide as the scutellum; markings of the second abdominal segment often obsolescent; hind femora more thickened; hypopygium two to three times normal size; presutural black band of thorax faint to obsolescent.......................... *rufiventris* Macq.

Eristalis rufiventris Macq.

(Plate I, Fig. 4).

Male and Female. Antennæ and arista light brown; facial stripe and ground color of face light reddish brown; cheeks black, in one specimen dark reddish brown. The gray of the thorax is tinged with brown. The presutural black band is very narrow to obsolescent. The post sutural black band is about as wide as the post-sutural gray band. The black

attenuated markings of the second abdominal segment are often obsolescent (faintly indicated), and usually take the shape of a triangle. In one specimen it takes the form of a median unattenuated band. In another all that remains is a small reddish spot. Markings of the third and fourth segment not different from those characteristic for the *albifrons* group save that they may be obsolescent. Femora shining black; apices of femora together with greater part of tibiæ reddish. Hypopygium two or three times the normal size. Length 8–9 mm.

The species is thus characterized by its more strongly reddish coloration, much larger hypopygium, different arrangement of the bands, etc. It most resembles *cubensis*. Besides differing in the above mentioned characters, the presutural black band is much narrower (than in *cubensis*), and the postsutural gray band much wider than (the same band) in *cubensis*. The hind femora are slightly more thickened.

Five females and four males, San Pedro, Honduras; Los Amates, Guatemala; Corumba, Brazil. (O. S. U. coll.).

Eristalis fasciatus Wied.

(Plate I, Fig. 6; Plate II, Fig. 15).

Male and Female. Antennæ dark reddish brown; facial stripe and cheeks shining black, in one or two specimens dark reddish. Ground color of face dark or blackish. Pile of face, light, of front and vertex dark. Thoracic dorsum almost entirely black; a single narrow, presutural ashy band (the region between and in front of humeri is also ashy). Scutellum yellow. Black band of second abdominal segment wide, nearly half as wide as long, unattenuated in the male, rarely in the female; frequently runs to the lateral margin posteriorly. Third segment not differing from the typical form except that the black is often of greater extent. Legs wholly shining black though tarsi sometimes in part light colored. Length, 10 to 12 mm.

The species is an unusually dark form; it is a trifle larger in size. The hind femora, like *rufiventris*, are decidedly thicker than normal. Its nearest allies are *triangularis*, *floreus* and *atrimanus*. The former has the ashy band of the thorax broadly interrupted; the last two differ in the color of the legs, antennæ and the configuration of the black on the second abdominal segment. Specimens have been studied from Bartica, B. Guiana; Los Amates, Guatemala, and Caura Val., Venezuela.

Eristalis triangularis Giglio Tos.

(Plate II, Fig. 19).

Female. Antennæ light reddish brown; facial stripe and ground color of face yellowish brown; cheeks black. Pile of front and face light in color, chiefly black just above the antennæ and on the vertex. Dorsum of thorax largely black; a slender, presutural, ashy band, interrupted medianly for about a third of its width. Scutellum yellow. Black of second segment of abdomen a rather well defined triangle, its base on the posterior margin, reaching to the lateral margin, its two other faces somewhat concave; apex usually reaching the anterior margin. Third and fourth segments similar, the black greater in extent. The light color of the abdomen decidedly reddish. Wholly opaque save for two small spots in the middle of the fourth segment, and a narrowly interrupted transverse band in the middle of the fifth segment. Femora, except tips, distal two-thirds of hind tibiæ, shining black. Tarsi blackish, otherwise legs light yellowish brown. Length, 8 to 11 mm.

Only known from the female. Five specimens. Los Amates, Gualan, Mazatenango, Guatemala; one specimen from Cuba seems to belong here. (O. S. U. collection). Resembles *atrimanus* most, perhaps, but distinct in the interrupted ashy band of the thorax, the more distinct triangles of the abdomen, etc.

This seems to be the species discussed by Williston as "sp. no. 14" (Biol. Cent. Amer.). While I have said "only known from the female," Williston's notes imply that he had the male likewise, and further that it agrees with the female in the widely interrupted band of the thorax.

Eristalis albifrons Wied.

(Plate I, Fig. 7).

Male. Antennæ light yellowish brown to dark reddish brown and facial stripe of nearly the same color. Ground color of face light. Cheeks black. Pile of face and front white (slightly darker upon the vertex). Thorax black, a very narrow gray band just before the scutellum, a still narrower black band between it and the scutellum, and a similar, wider, gray band before the suture, the latter a trifle less wide than the intervening black band. The prescutellar band is wanting in two specimens but these show traces of such. Scutellum yellow, slightly reddish. The markings of the second abdominal segment consist of a quite narrow median band or stripe of black, always meeting the anterior margin, rarely obsolescent posteriorly, about four or five times as long as wide. The black of third segment a posterior marginal band, produced medianly to meet the band of the second segment, always interrupted by the narrow yellow posterior margin of that segment. Thus the yellow

of the second and third segments is confluent in its whole width. Fourth segment entirely black. All the segments opaque save for an interrupted shining band on the fourth segment. Legs largely shining black; apices of femora and larger part of tibiæ, and tarsi, light to dark reddish brown.

Female. Differs chiefly in having the median black stripe of the second abdominal segment dilated gradually very slightly, posteriorly; never more than twice as broad posteriotly as anteriorly. Black of following segments usually of greater extent. Sometimes reddish spots in the anterior corners of fourth segment. Pile of vertex interspersed with black. Length, 10–11 mm.

Quite distinct in the very narrow, unattenuated, median band of the abdomen. Nearest to *cubensis*. The latter has the bands of the abdomen only about one-half as wide as long, or wider, often extended laterally to the sides of the second segment, the yellow of the second segment slightly greater in extent, the prescutellar band not quite so wide, etc. The gray of the thorax is wholly without any tinge of brown or yellow. Several specimens have the abdomen peculiarly whitish; in the majority it is deep yellow and even tinged with reddish. One of the two or three species in the group with any appreciable sexual dimorphism. Material studied is from San Jose, Guatemala; Cameron, La.; Lakeland, Fla., and Yucatan, Mexico.

Eristalis pusillus Macq.

(Plate I, Fig. 2; Plate II, Fig. 17).

Male and Female. Antennæ light reddish brown; facial stripe of nearly the same color. Ground color of face light. Cheeks black, sometimes dark reddish brown. Pile of face and front pale yellowish, in the female with considerable, in the male with slight black pile on the vertex. Thorax black, with the exception of the entire area before the suture, which is ashy gray and slightly tinged with yellow. Thus the black and ashy bands are of nearly equal width. Scutellum yellow. Black of the second abdominal segment a triangle, its base on the posterior margin, which may or may not be extended laterally to the sides, rarely failing to meet the anterior margin. A median black spot on the third segment, sometimes likewise a triangle. Legs largely shining black, narrow apices of femora, base of hind tibiæ, greater part of front and middle tibiæ reddish brown. Length, 8 to 11 mm.

Quite unique in having the thorax marked with two wide bands of black and gray respectively. Nearest to *alhambra*, but in that form there is a comparatively wide, gray, pre-

scutellar band in addition to the anterior band; the black of the second segment a wide, unattenuated stripe, etc.

Specimens have been studied from Los Amates and Gualan, Guatemala; Boniato, Cuba; San Angelo, Brownwood, Roosevelt, Harlingen, Texas; Mexico.

Eristalis atrimanus Lw.

Male. Antennæ, facial stripe, cheeks and ground color of face black. Pile of face silvery white. Pile of front and vertex white interspersed with a little black. Dorsum of thorax black, a rather narrow, uninterrupted, presutural ashy band. Scutellum deep yellow tinged with reddish. The black of second abdominal segment extends forward to the anterior margin in the form of a slightly attenuated median stripe, basally extending to the lateral margins, thus forming an inverted "T." On the third segment the black is in the form of a rather wide (one-third the width of the segment) median band that reaches the anterior margin and extends narrowly, basally, to the sides. Fourth segment entirely black. Femora, except narrow apices, narrow bases of middle and hind tibiæ and basal half of front tibiæ, shining black; remainder rather light brownish yellow.

One specimen, female, Kingston, Jamaica; collection Boston Soc. Nat. Hist. One male, Boniato, Cuba, collection Ohio State University.

The female specimen is certainly this species, but differs in one or two particulars. The antennæ are reddish brown and the facial stripe very dark reddish. The pile of face and front is pale yellowish rather than silvery. Thorax the same as in the male. The black of the second segment agrees except that it is in the form of a triangle, the apex not quite reaching the anterior margin, the two anterior sides slightly concave. Third segment as in the male. On the fourth segment are very small yellow spots in the anterior corners. The legs are considerably lighter in color. Length, 12 mm.

Although only two specimens have been studied, the species seems easily distinguishable by the possession of a single, narrow, presutural ashy band; the black of the second segment reaches the sides of the segment posteriorly, etc. This latter character separates it from *floreus* and *fasciatus*. Further, *floreus* has the scutellum and the light color of the abdomen, clear, light yellow; in *atrimanus* it is deep yellow and slightly tinged with reddish.

Eristalis taenia Wied.

Female. Antennæ dark reddish brown. Facial stripe and ground color of face light brownish yellow. Cheeks reddish brown. Pile of lower front light, of upper part black; pile of vertex light. Thorax black, the whole area before the suture ashy, except for a quite narrow black band that is obsolescent on either side. Black of second abdominal segment a triangle, its apex reaching the anterior margin, not reaching the sides posteriorly but with a small black spot in the posterior corners. Third segment similar but with a black band the whole length of the lateral margin on either side. Fourth segment entirely black. Greater part of the legs light yellowish brown; basal half of the femora, hind tibiæ slightly, and distal joints of tarsi dark brown. The gray of the thorax slightly tinged with brown. Length, 11 mm.

One female. Sao Paulo, Brazil.

Closest, perhaps, to *pusillus*, from which it is distinguished by the prescutellar black band, the lighter colored legs, etc.

Eristalis cubensis Macq.

(Plate I, Fig. 1; Plate II, Fig. 14).

Male and Female. Antennæ a light reddish brown. Facial stripe light to dark reddish brown, cheeks black. Ground color of the face brown, pile light in color; pile of front and vertex inter-mixed with black. Thorax black, a narrow gray prescutellar band and another gray presutural band of about the same width. Scutellum deep yellow, often tinged with reddish. Black of second abdominal segment a rather wide, median, unattenuated band, about twice as long as wide, slightly dilated posteriorly; black of third segment a round median spot continuous posteriorly with a marginal spot or band, that usually runs narrowly to the posterior margin. Fourth segment wholly black, rarely with small light spots in the anterior corners. The female differs in having the black posterior marginal band of the second segment extended to the sides, and a greater proportion of yellow on the remaining segments. Legs largely shining black; bases of hind tibiæ narrowly, of front and middle tibiæ more widely, yellowish. Length, 10–11 mm.

Nearest to *E. albifrons*, with which it has been confused. Distinct in the wide median band of the second segment of the abdomen; further, this band usually extends to the sides posteriorly, in the female of *cubensis*, rarely in the female of *albifrons*. The two black bands of the thorax distinguish it from *alhambra*.

Material studied is from Los Amates, Santa Luchia, Guatemala; San Pedro, Honduras; Port Antonio, Jamaica; Tupelo, Oxford, Miss.

Eristalis alhambra n. sp.

(Plate II, Fig. 10).

Male. Antennæ reddish brown, facial stripe black, ground color of face dark brownish; in one specimen the facial stripe is rather light brown and the ground color likewise light. Pile of face silvery white. Pile of front and vertex light, of upper part of front black. Cheeks black. Thorax black, the whole area before the suture ashy gray and a second ashy band before the scutellum. The black band is thus comparatively limited in extent; it is about the same width as the prescutellar gray band. It is the only black thoracic band in as much as the extremely narrow black border just in front of the scutellum is scarcely noticeable or lacking.

Gray of thorax untinged with yellowish. Scutellum clear yellow. Black of second abdominal segment a wide median band, always attaining the anterior margin, slightly dilated posteriorly but never reaching the lateral margins. Black of third segment a similar band of nearly the same width, produced posteriorly to the sides. Fourth segment nearly all black; narrow yellow spots in the anterior corners. Legs not differing greatly in coloration from the other members of the group; hind femora a trifle more thickened, resembling *rufiventris* and *fasciata* in this respect.

Female. The female differs chiefly in that the black of second abdominal segment is wider and is extended to the lateral margin posteriorly, leaving the yellow in the form of two round spots. Black of third segment considerably greater in extent. Fourth segment wholly black. Length, 8–9 mm.

Closest to *E. pusillus*, but this species has only one ashy band on the thorax.

Holotype male, paratype male and allotype female. Collection of Mr. W. M. Davidson, Alhambrae, Calif. Paratype male and two females, Mills Creek Canyon and Redlands, Calif. (F. R. Cole collection).

Eristalis floreus n. sp.

(Plate I, Fig. 3).

Male. Antennæ light reddish brown; facial stripe reddish, in one specimen black; cheeks black. Pile of face pale yellowish white, ground color light; pile of front and vertex light, inter-mixed with black. Thorax black, a comparatively narrow ashy band, tinged faintly with yellowish, just before the suture. Scutellum clear yellow. Black of second abdominal segment a slightly acute triangle; its base on the posterior margin, not reaching the sides; its apex reaching the anterior margin. Third segment with a round black median spot on the anterior half, continuous posteriorly with a black band on the margin, the latter

reaching the sides of the segment. Fourth segment wholly black. Legs shining black, narrow apices of femora, base of hind tibiæ narrowly, of front and middle tibiæ more widely, yellowish.

Female. The female differs in the black of the second segment being narrowly extended posteriorly, to the lateral margin. In this respect it comes very close to *E. atrimanus*, which has the black reaching the lateral margin much more widely. *E. atrimanus* is a reddish yellow form, with the scutellum tinged with reddish. The lighter color of floreus is a clear, light yellow. As the male seems quite different, I have considered the two forms distinct. The species *floreus* really resembles *fasciata* more closely; like that species it is of a pronounced blackish color, but is readily separated by the attenuated spots of the second abdominal segment, the less thickened femora, etc. Length, 10–11 mm.

Holotype and paratype male and allotype female, Bartica and Kartabo, British Guiana, (collection O. S. U.). Paratype male, (collection of writer).

Eristalis vinetorum Fabr.

(Plate I, Fig. 9).

Male. The antennæ, facial stripe and general color of face light reddish brown. Cheeks reddish brown. Pile of face, front and vertex, pale yellowish white, immediately around the ocelli, black. Thorax gray, with a slight brownish tinge; a wide black band behind the suture, and a similar band of about half the width of the former, before the suture. The prescutellar band is somewhat convex on its posterior margin. Thorax usually feebly shining on the posterior half. Scutellum reddish brown, darker in the center and basally. Black of second abdominal segment opaque, a narrow median stripe somewhat dilated anteriorly and meeting the anterior margin, extended posteriorly in a dark marginal band to the sides of the segment. Second segment otherwise shining, reddish brown or fulvous. Third segment with a round black spot medianly on the anterior half, continuous posteriorly with an opaque black marginal band, reaching the sides; otherwise shining reddish brown. Fourth segment with narrow marginal, opaque black bands anteriorly and posteriorly, and between, a wide metallic greenish or black band. Segments with the usual narrow yellow bands on the posterior margins. Pile of whole thoracic dorsum, and of abdomen except on the black areas where it is black, short, abundant, brownish yellow to fulvous. Legs shining reddish to yellowish, darker on the femora, sometimes black on the hind femora. Pile light yellow. Hind tibiæ considerably thickened and somewhat arcuated. A row of strong, short, black bristles, above and below. Hind femora considerably thickened. Wings slightly infuscated about the middle on the anterior half.

Female. Usually with a greater degree of black on the abdomen; frequently the yellow areas of the third and fourth segments are wholly shining black. Length, 11–14 mm.

Very different in its reddish brown or fulvous coloration, in which it approaches quite closely *E. obsoleta*, differing in the fasciate thorax, etc. Besides differing from the other members of the group as above mentioned, the abdomen is in a very large degree shining; the typical species are almost wholly opaque. Recorded from numerous Southern States, as well as Ind., Mex., Cuba and Brazil.

Eristalis transversus Wied.

(Plate I, Fig. 5).

Male. Antennæ dark reddish brown, arista slightly plumose basally; cheeks and facial stripe shining black; pile of face and occiput white, of front, and vertex near the ocelli, black; ground color of face black. Thorax black, the whole area in front of the suture brownish gray, somewhat shining; a rather wide band, with opaque black on either side, behind the suture, considerably shining. Scutellum yellow. Pile of whole thorax yellowish. First segment of abdomen black; second with a widely obtuse black triangle, its base on the anterior margin and extended in a median band to meet the black posterior, marginal band, the posterior marginal band extending to the sides; two large yellow triangles or spots are thus left on either side of the second segment.

Third segment yellow, with a black posterior marginal band, and a median, characteristically rectangular spot, continuous with the band but not reaching the anterior margin. Fourth segment entirely black. Abdomen opaque, a shining cross band on the third and fourth segments. Legs black, the narrow apices of the femora, base of hind tibiæ, front and middle tibiæ except apices, and greater part of front and middle tarsi, yellow. Wings nearly hyaline.

Female. Differing markedly in having the third segment wholly black, save for the customary posterior marginal bands. Front and middle femora, and basal half of hind femora usually, likewise yellowish. Length, 7–12 mm.

A characteristic, well known species differing from the typical members of the group in the points mentioned under the group description. It further departs from this type in the shining, even sometimes metallic, bands of the thorax, plumose arista, etc.

Widely distributed over the Eastern half of the country, Canada to Florida, and West to Texas.

Eristalis hortorum Fabr.

(Plate I, Fig. 8).

Male. Antennæ deep yellow; facial stripe and ground color of face light yellowish or reddish brown; cheeks black. Pile of face and front,

as well as vertex and occiput, golden, black around the ocelli. Thorax black, rather shining posteriorly; a narrow band before the scutellum, a second band before the suture and the region below and between the humeri, deeply yellow, tinged with brownish. Scutellum brownish red. Pile of thorax almost wholly deep yellow, black on the pteropleura. Black of second abdominal segment similar in pattern to that of *transversus;* sidespots shining brownish red. Third segment black, reddish spots in the anterior corners; a narrow opaque black band both anteriorly and posteriorly. Fourth segment black, likewise with narrow opaque margins. Legs wholly deep shining red, more orange to yellow on the front and middle pairs. Hind femora considerably thickened. Wings with a dark brown band on outer anterior half, yellowish on basal half, hyaline posteriorly. Length, 12 mm.

Female. As in *transversus* the female has the third abdominal segment wholly without light spots in the anterior corners.

One male and one female, San Juan and Aibonito, Porto Rico; recorded by Will. from San Domingo.

Eristalis minutalis Will.

Female. Antennæ reddish brown; facial stripe dark reddish, nearly black; ground color face similar; cheeks black. Pile of face, front and occiput light, on the vertex dark. Thorax opaque gray, a rather wide band just behind the suture, a second band about half the size of the first before the suture, and the narrow posterior marginal band of the thorax, black. Scutellum yellow, blackish basally. Second abdominal segment black save for a round yellow spot on each side, not reaching the lateral margin and surrounded by black on all sides. Third segment black, with yellow spots in the anterior corners, reaching the margin. Fourth segment similar, yellow spots very small. Legs not differing greatly from the other members of the group except that the hind femora are somewhat thickened. Length, 6–8 mm.

Williston records both male and female of this species and remarks that the scutellum seems variable in the amount of black.

Quite apart from the other species in its diminutive size, thickened femora, etc.

One female, San Pedro, Honduras, (O. S. U. coll.); one male, Kartabo, British Guiana, (coll. C. H. Curran). The male, which apparently belongs here, has the scutellum wholly yellow.

EXPLANATION OF PLATES.

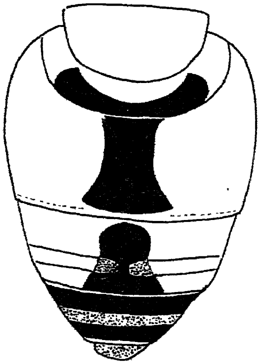
Plate I.

Abdomens of *Eristalis; albifrons* group. On the drawings black represents opaque black; heavily stippled areas represent shining black, and lightly stippled areas depict brown. Uncolored areas show yellow or red. Drawings by camera lucida. Slight differences in shapes of abdomens should not be considered seriously as they are likely to be due to shrinkage or drying.

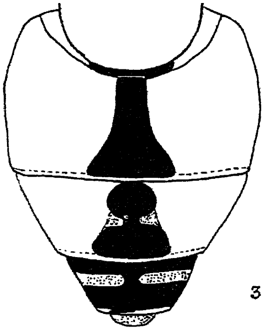
Plate II.

Drawings of *Eristalis; albifrons* and *furcatus* groups. Figures ten to thirteen represent abdomens, Figures fourteen to twenty-one the thorax, and Figure twenty-two, a lateral view of the head.

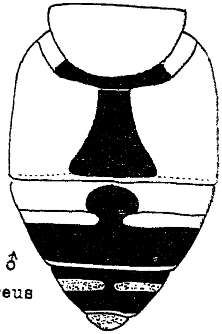
PLATE I.



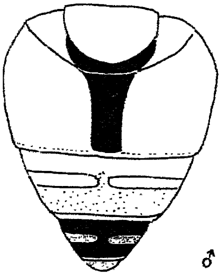
1 .cubensis ♂



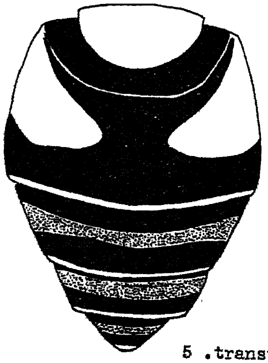
2 . pusillus ♂



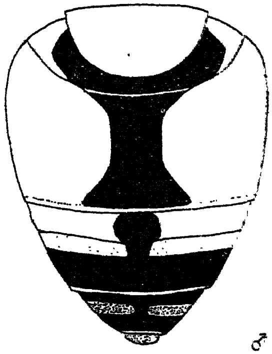
♂ 3 .floreus



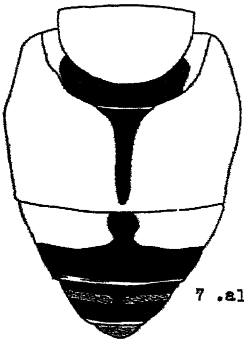
♂ 4 .rufiventris



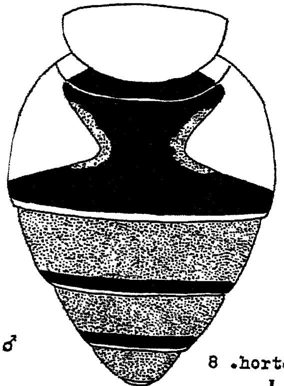
5 .transversus ♀



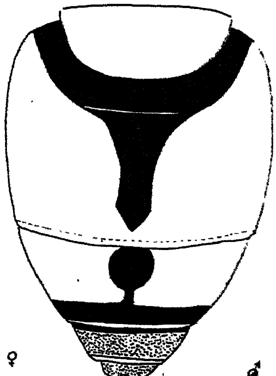
♂ 6 .fasciata



7 .albifrons ♂



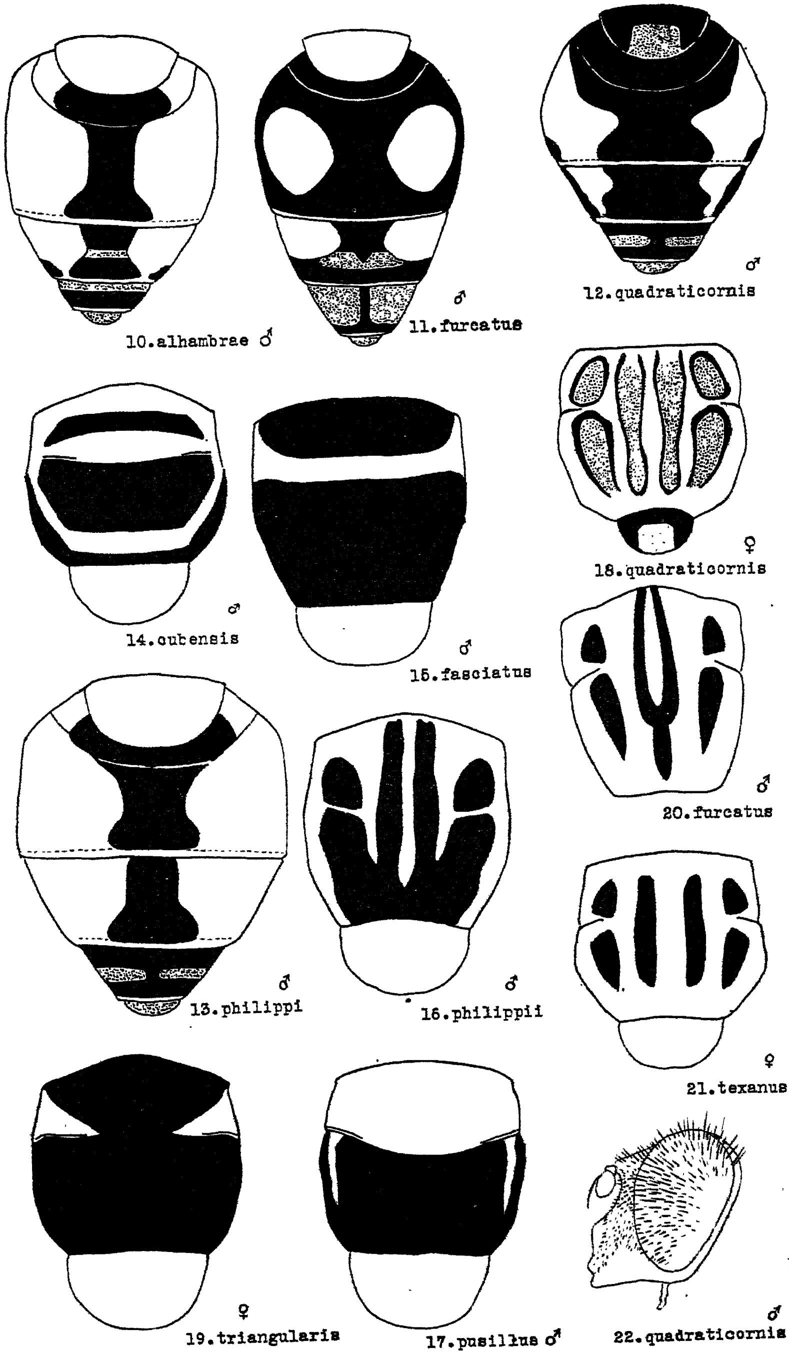
8 .hortorum ♀



♂ 9 .vinetorum

I.

F. M. Hull del.



10. alhambrae ♂
11. furcatus ♂
12. quadraticornis ♂
14. cubensis ♂
15. fasciatus ♂
18. quadraticornis ♀
13. philippi ♂
16. philippii ♂
20. furcatus ♂
21. texanus ♀
19. triangularis ♀
17. pusillus ♂
22. quadraticornis ♂

F. M. Hull del.

FOUR UNDESCRIBED SPECIES OF WATERSTRIDERS (HEMIP.-GERRIDÆ).

C. J. DRAKE AND F. C. HOTTES
Iowa State College, Ames, Iowa.

This paper contains the descriptions of four new species of waterstriders of the family Gerridæ. Of these, two are known only from Colorado, one from Colorado, Utah, Iowa and Oregon, and the other ranges from Colorado to Maine. Dr. H. B. Hungerford and Dr. Herbert Osborn have kindly permitted the writers to study the specimens of Gerridæ in the collections of the University of Kansas and the Ohio State University.

Gerris (*Limnoporous*) *notablis*, n. sp.

Very closely related to *G. rufoscutellatus* Latr. but separated from it by its much larger size, longer legs, the more prominent carina of the pronotum, and the difference in the proportional lengths of the antennal segments. In *rufoscutellatus* the posterior margin of the sixth segment is more truncate and widely excavated and the apical spines do not usually reach the end of the second genital segment; in *notabilis* the last dorsal segment and connexivum of the abdomen are more roundly excavated and the apical spines are stouter, longer, and generally reach to the tip, or a little beyond the tip of the last genital segment. Length, male, 15–16 mm.; female, 15.5–16.1 mm.; width, male, 2.2 mm.; female, 2–2.32 mm.

Very elongate, moderately robust, rufescent or ferrugineous; head, a large spot on each side of the pronotum in front, sides of pronotum and nervures of hemelytra blackish brown; body beneath densely clothed with long silvery hair. Antennæ brown at the base, growing blackish brown towards the tips; first segment considerably longer than any of the others, second segment much shorter than the first and longer than third or fourth, the fourth a little shorter than the second and a little longer than the third; other characters about the same as in *rufoscutellatus*.

Male: The intermediate and posterior legs much longer than in *rufoscutellatus*, the posterior margin of the first genital segment beneath nearly truncate; antennæ longer than in the female.

Female: Very similar to the female of *rufoscutellatus*, but larger, with longer legs; the connexivum terminating in a stouter and longer spine.

Holotype, macropterous male, *allotype*, macropterous female, taken on a small pond, elevation 9,300 feet, Pingree Park, Colorado, August 18, 1924, by the authors, in the collection of C. J. Drake. *Paratypes:* Pingree Park, Colorado, August, 1924, by Dr. P. B. Lawson and Prof. R. H. Beamer, and by the authors, August 18 to 24, 1924; Estes Park, Colorado, August 27, 1924, by the authors; Corvallis, Oregon, June 1, 1899; Ames, Iowa, July 24, 1924, by C. J. Drake; Emery County, Utah, July 30, 1922, and September 13, 1921, by Mrs. Grace Wiley.

This species ranges from Oregon to Iowa and inhabits ponds and lakes. It is very closely related to *Gerris rufoscutellatus* Latr.; on account of its antennal and genital characters and much longer legs, it seems best to consider *notablis* a distinct species rather than a variety of *rufoscutellatus*.

G. notablis, n. sp., was taken in company with *G. pingreensis*, n. sp., at Pingree Park and Estes Park, Colorado; with *G. comatus*, n. sp., *G. buenoi* Kirk., *G. marginatus* Say, *G. rufoscutellatus* Latr., *G. remigis* Say, *Trepobates pictus* H. S., *Metrobates hesperus* Uhl., *Rheumatobates rileyi* Bergr., *Mesovelia mulsanti* White, *Microvelia borealis* Bueno, and *Merragata foveata* Drake, at Ames, Iowa.

Gerris (*Aquarius*) *nyctalis*, n. sp.

Differs from *G. remigis* Say by its darker color and shorter body, legs and antennæ, especially the first segment. Length, male, 11.9–12.4 mm.; female, 11.5–13 mm.; width, 2.6–3.2 mm.

Apterous form: Pronotum blackish, sparsely pubescent, with the posterior margin broadly rounded, the median carina distinct, the median anterior stripe yellowish brown. Antennæ moderately long, blackish; first segment distinctly shorter than in *remigis*, twice the length of the second, the second very slightly longer than the third and the fourth a little longer than the second. Abdomen above blackish, the pubescence sparse and extremely short, each of the last four segments usually with a longitudinal, discal, bluish gray streak; connexivum broad, with a very small, brownish spot along the outer margins between each segment; terminating in a broad, stout, moderately long spine, the tip of which projects slightly inwardly and upwardly. Legs moderately long, blackish above, the tips of intermediate and hind femora extending a little beyond the tip of the abdomen. Body beneath brownish black, prosternum, coxæ and part of trochanters yellowish or brownish.

Male: Venter broadly flattened; sixth segment distinctly depressed in the middle, the posterior margin raised and very deeply, broadly and roundly notched, fringed with rather long, yellowish hairs. Genital segments blackish, the first segment with the median ridge narrower than in *remigis*.

Female: Venter distinctly broader than in remigis; genital segments blackish; pronotum very broadly rounded posteriorly.

Macropterous form: Pronotum with anterior lobe depressed, especially in the middle; humeri large and prominent; posterior margin not so broadly rounded as in the apterous form. Hemelytra reaching almost to tip of first genital segment, the nervures brownish black and sparsely pubescent.

Holotype, apterous male, and *allotype*, apterous female, taken in U. S. National Park, near Estes Park, Colo., August 27, 1924, by the authors, in collection of Carl J. Drake. *Morphotype*, macropterous female, collected with holotype. *Paratypes* and *morphotypes* collected with holotype in collections of Iowa State College, Colorado Agricultural College, and the authors. This species was collected about nine miles from Estes Park, on a small beaver pond along the Bear Lake road. It was taken in company with *G. pingreensis*, n. sp. and *G. comatus*, n. sp.

Gerris (Gerris) comatus, n. sp.

Size and general aspect very similar to *G. marginatus* Say and *G. alacris* Hussey; male readily distinguished from either of these by the two prominent tufts of long hair, one on each side of the first ventral genital segment; the omphalium of the metasternum is prominent, but not as large or as prominent as in *alacris*. The female is rather hard to distinguish from the female of *marginatus*, but the first genital segment above is a little broader, and the terminal spine of the connexivum is a little more blunt, the tips of the spines usually darker and clothed with longer hairs. Length, male, 7.3–8.2 mm.; female, 8–8.9 mm.; width, male, 2.3–2.5 mm.; female, 2.6–2.8 mm.

General color of body, legs and antennæ very similar to *G. marginatus;* in the macropterous form hemelytra slightly variable in length and either reach almost to, or more or less cover the first genital segment. The hemelytra in the brachypterous form do not completely cover the fifth abdominal segment. The apterous form is unknown. The proportional lengths of the antennal segments are almost identical with *marginatus*.

Male: The sixth dorsal segment deeply, broadly and roundly emarginated, terminating in very short spines. Venter indistinctly carinate, the third, fourth, fifth and sixth segments somewhat depressed; sixth segment deeply and roundly excavated. First genital segment with the sides deeply depressed and with a prominent tuft of long hair in each depression.

Female: Very closely allied to the female of *marginatus*, the terminal spines of the sixth segment slightly shorter, a little more blunt and clothed with longer hair; first genital segment above slightly shorter and broader than in *marginatus*.

Holotype, macropterous male, and *allotype*, macropterous female, taken on small pond, Y. M. C. A. Conference grounds, Estes Park, Colorado, August 27, 1924, by C. J. Drake and F. C. Hottes. *Morphotypes;* male, taken on Sandusky Bay,

Cedar Point, Ohio, July, 1912, by C. J. Drake, and female, from Mirror Lake, O. S. U. Campus, Columbus, Ohio, Sept. 10, 1913, by C. J. Drake. Many *paratypes* and *paramorphotypes* from U. S. National Forest, Estes Park, Colorado, August 27, 1924, by the authors; Ames, Iowa, July 24, 1924, by C. J. Drake, H. M. Harris and F. C. Hottes; Ames, Iowa, October 18, 1924, by authors; Colorado, long winged male No. 2021; Buckeye Lake, Ohio, June 20, 1916, and June 30, 1916, by C. J. Drake; Sandusky, Ohio, July, 1912, by C. J. Drake; Columbus, Ohio, September 19, 1913, by C. J. Drake; Rice Lake, Wisconsin, August 28, 1912, by A. C. Burrill, collected sweeping; Bar Harbor, Maine, July 29, 1916, by Herbert Osborn.

Paratypes in the collections of Iowa State College, Colorado Agricultural College, Ohio State University, H. M. Harris and the authors. *Paramorphotypes* in the collection of the authors.

This species has been confused in collections with *G. marginatus* Say. The males are very distinct and not easily confused with *marginatus* or other allied forms.

Gerris (*Gerris*) *pingreensis*, n. sp.

Allied to *G. buenoi* Kirk. and with similar color markings on the pronotum, but readily separated from it by the shorter basal segment of the antennæ, the distinct median carina of the pronotum and the much differently formed sixth ventral and genital segments of the male. Length, male, 9–9.85 mm., female, 9–10 mm.; width, male, 2–2.2 mm., female, 2.1–2.5 mm.

Antennæ moderately long, brownish black; first segment a little longer than the fourth and subequal to the second and third conjoined; third segment slightly shorter than the second. Legs moderately long, blackish above and brownish beneath. Pronotum broader, more deeply pitted and more roughened than in *G. buenoi*, the posterior margin very broadly rounded; sparsely clothed with extremely short, golden pubescence; anterior lobe with the short discal and the marginal stripes brownish; body beneath blackish, with rather short, silvery hairs; genital segments brownish or brownish black. Rostrum reaching to the mesosternum, the apical segment smooth and blackish.

Macropterous form: Humeri prominent, the margin beneath brownish. Hemelytra not completely covering the genital segments; nervures blackish brown, the pubescence sparse and extremely short.

Apterous form: Pronotum much more flattened, and the carina more prominent than in winged specimens; anterior lobe strongly depressed on each side of median line; posterior margin very broadly rounded and slightly carinate.

Male: Venter broadly, concavely depressed, with a median, longitudinal carina; sixth segment with the deep, broad furrow becoming wider and deeper posteriorly, as deeply but not as widely notched as *buenoi*. Genital segments and ventral projection of first segment narrower than in *buenoi*. Connexivum terminating in a broad and very short spine.

Female: Venter somewhat flattened; in the apterous female, first abdominal segment above with a prominent tubercle. Connexivum terminating in a broad, moderately long, upwardly projecting spine, the tip of which is black.

Holotype, macropterous male, and *allotype*, macropterous female, taken on a small pond, elevation 9,300 ft., Pingree Park, Colorado, August 18, 1924, by the authors, in the collection of Carl J. Drake. *Morphotypes*, apterous male and female, collected with types. Several hundred *paratypes* and *paramorphotypes:* Pingree Park, August 16–23, 1924, by the authors; Pingree Park, August 18–23, 1924, by Doctor P. B. Lawson and Professor R. H. Beamer; Estes Park, and U. S. National Forest near Estes Park, August 27, 1924, by the authors. *Paratypes* and *paramorphotypes* in the collections of Iowa State College, Kansas State University, Colorado Agricultural College, Ohio State University, U. S. National Museum, and the authors. This species is very abundant on ponds and small lakes in high altitudes. It was taken in company with *G. nyctalis*, n. sp. and *Gerris* sp. at Pingree Park, and with *G. nyctalis*, n. sp. and *G. comatus*, n. sp. in Estes Park and in the U. S. National Forest.

Date of Printing, January 27, 1925.

The Ohio Journal of Science

Vol. XXV MARCH, 1925 No. 2

PHYSIOGRAPHIC HISTORY OF FIVE RIVER VALLEYS IN NORTHERN OHIO*

GEORGE D. HUBBARD AND MILTON M. CHAMPION

Department of Geology, Oberlin College.

Introduction.

The Area Studied.

The area studied is a portion of northern Ohio about midway in the state from east to west and north of the divide between the Erie and Ohio drainage basins. It embraces parts of Sandusky, Erie, Huron, Lorain, and Cuyahoga counties with portions of Seneca, Wyandot, Crawford, Medina and Summit counties farther south. Field work actually covered the five valleys of Sandusky, Huron, Vermilion, Black and Rocky rivers, with their main tributaries.

Physiographic Provinces.

The region is located on the Lake and Till Plains south of Lake Erie, so its history is linked up rather closely with that of the Great Lakes and of Glaciation in North America.

Structure, and General Physiographic History.

The structure of the area is simple; upper Paleozoic strata dip southeast on the eastern limb of the Cincinnati anticline. The strata lie nearly horizontal. There are no local anticlines or synclines of any importance. There is, however, in some places local bowing up of Devonian and Mississippian shales

*In its original form this paper was submitted by Mr. Champion as a part of the requirement for the degree of Master of Arts in Oberlin College, 1924. Since the degree was granted the paper has been considerably reduced in size, but the authors do not think its value as description and explanation has been impaired. Practically all of the territory described in this paper has been seen by both authors and the paper in its present form is in all respects a joint paper.

accompanied by slight shearing, faulting and brecciation. At Lodi is a fault of 8 feet in the Cuyahoga formation. The structure has very little to do with the subsequent history of the rivers. Initial drainage may have followed jointing and fissuring in the shales, but as there are no important faults, this does not seem likely.

The limestones in the western part of the area dip underneath the black Ohio shales in the central part, and these in turn pass under Berea and Cuyahoga sandstones and associated shales in the eastern part.

Throughout Tertiary time erosion was going on in the Great Lakes region. This Tertiary erosion cycle was very long, for it resulted in the broadening out of the valleys which probably opened in the direction of Hudson Bay, or an old St. Lawrence,[1] into very mature to old valleys. The Great Lakes occupy, in part these Tertiary river basins.[2]

If the weight of the glaciers warped down the crust of the earth that gives opportunity, now the ice is gone, for the present uptilting to the northeast, because when the glaciers withdrew, the resiliency of the earth's crust would respond with gradual uplift.[3] This may be a factor in the explanation of the location of the present drift divide, and more certainly of the lakes themselves. The drainage would not be away from the glaciers, as was the case south of the divide, with the making of outwash plains and eskers, but directly towards their retreating fronts, thus causing lakes wherever free flow was prevented.

There occurred five or six incursions of the glaciers; in our area three distinct invasions of the ice are known. The first two deposited a blue drift, most of whose remnants are unoxidized, analogous to the Illinoian; the third brought the light tan to brown oxidized drift of Wisconsin age. In the Interglacial Periods our area may have been the scene of re-excavation of broad Tertiary valleys or the carving of new connecting rock valleys, as suggested by buried gorges. These gorges could not have been the result of pre-Pleistocene erosion as at

---

[1]Grabau, A. W. Niagara Falls and Vicinity. New York State Museum Bull. 45, v. 9, Apr. 1901, pp. 37-54.

Spencer, J. W. W. Falls of Niagara. Canada Dept. of Mines, Geol. Survey Branch, 1905-6, pp. 412-428.

[2]Russell, I. C. The Laurentian Basin. Journal Geol., vol. 1, pp. 394-408.

[3]Hobbs, W. H. Earth Features and Their Meanings, pp. 344-347.

this time the area was broadly peneplained[4] and gorges would be inconsistent unless made immediately preglacially by waters partially impounded by the ice.

As the glaciers retreated for the last time proglacial lakes were formed, the first of which was Lake Maumee, covering some of western Ohio and of northeastern Indiana as far west as Fort Wayne. Its outlet was past Ft. Wayne by way of the Wabash, Ohio and Mississippi rivers. By farther retreat of the glacier front and the uncovering of a lower outlet, the Lake fell to the Whittlesey stage; its outlet was by way of Ubley, through central Michigan into Lake Chicago; from there its route was by way of Chicago, DesPlaines, Illinois and Mississippi rivers. The third lake stage was Lake Warren, whose outlet was through a lower channel north of Ubley and through Grand River into Lake Chicago; from there on the route was that of Lake Whittlesey. Finally, the drainage of the Great Lakes Region was reversed[5] in the direction of the St. Lawrence Basin due to farther warping and farther retreating of the ice and uncovering of lower outlets to the east.[6]

It is just before the Lake Maumee stage that the rivers[7] of our area began cutting through the till. Some of these rivers first emptied into wide embayments in the lake a little south of their present forks. The present branches of these rivers were separate streams at that time. The history of these rivers has been one of repeated rejuvenation with periods of stability caused by the stand of the temporary lakes, Maumee, Whittlesey and Warren, and by their rapid lowering from one level to the next. This stability is shown by temporary base levels with reference to shore lines. The present erosion cycle is one in which the post-glacial streams north of the drift divide are deepening their beds in lake clay, drift and in Paleozoic strata. These rivers may be characterized as young, although in places defended terraces demonstrate advanced youth.[8]

---

[4]Wilson, A. W. G. The Laurentian Peneplain. Journal Geol. Vol. 11, 1903, p. 645.

[5]Leverett, F. Mon. 53, U. S. G. S.

[6]Pirsson, L. V., and Schuchert, C. E. Textbook of Geology, 1915, p. 951.

[7]Carney, Frank. Abandoned Shore Lines of the Oberlin Quadrangle. Bull. Sci. Lab., Den. Univ., 1910, p. 102, f.

[8]Fisher, W. D. Terraces of the West River, (Conn). Proc. Boston Soc. Nat. Hist., Vol. 33, p. 40.

General Physiographic Features.

The area consists of Till and Lake Plains, sloping gently north to Lake Erie; the altitude of the drift divide is approximately 1,000 to 1,100 feet, that of Lake Erie 573 feet, while the altitude of the intervening Lake Plain is from 600 to 780 feet and the till plain rises from 780 feet up to the divide. The Till Plain is generally level, but slightly hummocky in places, whereas the Lake Plains have an even more level surface. These Lake Plains, however, are not wholly featureless, for they are set off into strips, roughly parallel with Lake Erie by ancient lake ridges.[9] These lake ridges are prominent and two are continuous across the entire state. They represent former Post Glacial lake levels. Butternut Ridge represents the Maumee shoreline, Middle Ridge the Whittlesey, and North Ridge the Warren shoreline. There were minor ridges such as Sugar and Chestnut, which may have been formed as off shore bars.

These ridges attain an altitude of from 10-20 feet above the surrounding lake plains and are perceptible as gentle elevations of very regular outline. Because of their good drainage these ridges are utilized for road beds, residences, orchards, gardens and cemeteries.

The main features of the present lake shore are escarpments of blue, fissile Ohio shale, rounded cliffs of buff, yellow lake clay or glacial drift, drowned river mouths with marshy inlets and several sections of sandy beach. Most of the streams run parallel with the lake beach a short distance just prior to their embouchure.

The Till and Lake Plains are being dissected by streams which have cut deep gorges in their lower courses[10] meandering in and out in a sinuous northerly direction.

DESCRIPTIONS OF THE VALLEYS.

This section will consist of a general description of each of the five valleys, followed by a more detailed description of each, from the sources to the mouth. The reader will do well if possible to read, with a topographic map* of each area discussed.

---

[9]CARNEY, FRANK. Abandoned Shorelines of Vermilion Quadrangle. Bull. Denison Univ. Sci. Lab., vol. 18, pp. 362-369.

[10]DEWEY, HENRY. Origin of Some River Gorges in Cornwall. Q. J. G. S., Vol. 72, p. 65.

*Maps covering the area may be ordered by name as shown on the Survey index sheet from the U. S. Geological Survey, Washington, D. C.

SANDUSKY VALLEY IN GENERAL.

The Sandusky River rises in Jackson township, Crawford County, in several creeks and runs around Crestline. The river flows southwest from the outer foot of Wabash moraine which it follows westward along its southern slope in a circuitous course until it breaks through the moraine on the Wyandot-Crawford county line. It then receives Broken Sword Creek and follows Ft. Wayne moraine until it breaks through that in Pitt Township, Wyandot County. From here it bears northward to McCutcheonville on the southern border of Defiance moraine. Near the moraine it receives Tymochtee Creek. For four to five miles it follows eastward along the southern side of Defiance moraine, then breaks through and proceeds almost northward past Tiffin and Fremont to the Bay. The river drains the larger part of Crawford, Wyandot, Seneca and Sandusky counties. The upper course drains Till Plains and three moraines, the middle part limestone and lake clay plains, while the lower reaches of the river drain only Lake Plain.

This is the longest river studied, having a water course of nearly a hundred miles. The river has a winding and irregular course except for four miles north of Tiffin, where the valley is narrow. From Fremont north the valley opens out very much and becomes shallow. Its few tributaries in its middle part almost make falls when they enter the main stream, for, because of their lesser volume, they are unable to keep up with it, in its erosion of the resistant Niagara limestone. Other tributaries from the east side are Sycamore, Willow, Morrison, Honey, Sugar, Indian and Bark creeks, while from the west side enter Muskellunge and Wolfe creeks. These tributaries often flow parallel with the main stream for the greater part of their courses, showing them to be the result of consequent drainage of the till and lake plain slopes.

The gradient of the river from Tiffin to the mouth is three and one-half feet per mile, from Tiffin to Fremont five feet per mile and from Fremont to the mouth one and two-thirds feet per mile. The gradients of the tributaries are generally much greater. From Fremont north, as we can see from the gradient of the stream, the river is nearer grade than above Fremont, showing the progress of erosion on the main stream.[11] This

[11]Davis, W. M. The Geographical Cycle. Geographic Essays, pages 266-272.

steeper gradient is also seen in the presence of several dams just north of Tiffin.

The river has exposed several buried valleys, one south of Fort Seneca, one two miles farther north, and one at Fremont. In the limestone the river gorge is shallow compared with the gorges of the other rivers in shale and sandstone. This is because of the difficulty with which the limestones are eroded. Near the mouth where the stream works in the lake clays its meanders are long and gradual and its banks are low. Here the river has almost reached grade as shown by contiguous marshy areas.[12]

The Sandusky Valley in Detail.

East of the Bucyrus Reservoir the valley of Sandusky River is the normal young valley in drift. A little flood plain has developed. West of the town the river meanders but scarcely systematically yet. It is not old enough. Most of the way for 20 miles to the southwest the river has entrenched itself in the drift. The upper bluffs are moderately steep and are far back from the stream. Three miles below Bucyrus there is an isolated hill close to the north side of the valley made by the combined action of main stream and small branch. In section 26, Pitt Township, the river through the work of a meander is about to cut off an oxbow around a hill, which may thus become isolated.

Two miles north of Wyandot there are two isolated hills in a very broad valley. The stream crosses an old valley here. Three miles southeast of Upper Sandusky the valley again widens and the stream follows a meandering course, in its broad flood plain; apparently another buried old valley.

North of Upper Sandusky the river cuts into hard resistant limestone quite continuously to Fremont. Just north of Upper Sandusky the river turns east where there are rock terraces on the north side of the valley and a broad flood plain on the south. The upper bluffs are composed of local lake clay and drift, while the lower ones are composed of resistant limestone. The river meanders northeast then zigzags north. This winding course is not due to normal shifting of the stream as is the case with normal meandering, but it is due to Till Plain irregularities.[13]

---

[12]NEWBERRY, J. S. Geol. Surv. Ohio, 1878, pp. 593, 611 and 625.

[13]LEVERETT, FRANK. Glacial Formations of the Erie and Ohio Drainage Basins. Mon. 41, U. S. Geol. Surv. pp. 583-604.

For two miles north of Old Tymoohtee the stream pursues a straight course in a limestone bed. The river then turns east, north, west, north, then south to get around glacial knobs which obstruct its path. This general crookedness continues to Mexico, where the river turns into the big Defiance moraine. Actual meanders begin at the moraine. They increase in size a little down stream as the river gets larger.[14] The meanders above the Maumee shoreline are an inheritance of those developed at the Maumee Lake stage. The old Maumee shoreline runs through Tiffin. In Maumee time the river meandered back and forth on its broad floodplain just as rivers now often do near their mouths. When the lake level fell the stream entrenched itself again giving rise to terraces. Just south of Tiffin the meanders become straighter as the river cuts deeper into its resistant limestone bed. The upper bluff slopes are often gently rounding, while the lower ones are straight and steep.

Right in the town of Tiffin the river is buttressed by walls so that its banks are not exposed. Where the river banks are exposed, however, they present a bold front of crystalline dolomitic limestone, capped by several feet of surface soil, probably mostly lake clay; limestone is more and more exposed as the river cuts its way into this resistant formation.

The terraces at Tiffin present a rolling surface and possess at least two levels with two fronts, the upper terrace front being more rounded on account of longer exposure to subaerial erosion. Willow Creek enters the Sandusky River about a mile northeast of Tiffin, where it falls over limestone ledges twenty feet in a half mile. A little farther down, Morrison Creek does the same thing. Occasionally the terraces are defended by projecting ledges of weathered rugged limestone, drab and rounded, cherty and full of holes.

The valley is the result of normal down-cutting with successive halts as shown by occasional submature upper terraces. Here the down-cutting has been so rapid that there are neither meanders nor floodplains. Long ledges of whitish limestone crop out along the river banks.

In this resistant rock, erosion produces gentle relief contours; and there are no decided bends in the river until it enters the drift of buried valleys, several miles north of Tiffin.

---

[14]DAVIS, W. M. Development of River Meanders. Geol. Mag. Decade 4, vol. 10, 1903, p. 146.

Evidences of former activity of the river are found in large potholes, undercuts and whirlpool basins high above the present stream.

The descent of the river across the limestone barrier is very rapid as shown by numerous rapids, a falls northeast of Tiffin and two dams farther down stream. The valley is rather narrow to a point three miles north of Tiffin, where it begins to widen out.

The Westerhouse road bridge is about four miles north of Tiffin. A quarter of a mile north of this bridge the river turns a little east and falls over rapids, then follow smooth reaches[15] for we have passed the limestone bed and entered a buried valley, attested by boulders of glacial origin in the stream, the absence of limestone outcrops and the presence of plastic clay banks. This clay is exposed in a road cut a half mile north of the bridge, also in the old Fort Seneca road. Just south of here a ravine enters containing no limestone. The terraces of this ravine are hummocky and irregular, characteristic of erosion in glacial drift. This is more evidence of the buried valley.

This absence of limestone continues in the river banks for a half mile. In the drift area the river has characteristic clay banks with a deeper concave curve of water erosion[16] and more irregular bluffs with even rounded tops at the sky line.[17]

The large curves of the river in Pleasant Township are not true meanders. They are too large for this stream as shown by comparison with other streams. They are due to inequalities of the drift surface upon which the river started and probably to some influence of buried valleys. The smaller curves one or two miles south of Fort Seneca are apparently true meanders and of the proper, consistent size for Sandusky River.

Two miles east of Fort Seneca the river enters and flows very tranquilly northward through a drift-filled buried valley section for about two miles, then it is again confronted by the limestone through which it cuts a rather straight and narrow valley, all the way to Fremont. Wolfe Creek and its East Branch are both on the rock or very near most of the way. Valleys are

---

[15]Davis, W. M. Elementary Physical Geography, p. 255.

[16]Merrill, J. H. Principles of Rock Weathering. Jour. Geol., Vol. 4, 1895, p. 850.

[17]Campbell, M. R. Drainage Modifications and their Interpretation. Jour. Geol., Vol. 4, p. 570.

shallow and streams are generally just crooked without systematic meanders. About three miles south of Kansas a rather large loop has been artificially cut off.

Near Fremont a relatively recent stream diversion has occurred. The river is on the rock and flowing east at Ballville. It formerly made a turn to the north then turned back west and went through the gorge (now a black earth celery farm) in the southwest part of Fremont, then flowed east again in the valley occupied now by the little creek. This diversion was caused by the meanders to the east cutting through the drift in a buried valley and thus allowing the river to straighten out and take the present course. The extreme western bluffs of the abandoned valley are seen at the Soldier's Hospital.

At the Lake Shore and Michigan Southern railroad bridge there is a broad, even flood plain on the east side of the stream. Limestone banks are soon lost sight of. North of Fremont the river makes long meanders and its banks are low and composed of till beneath and lake clay above; finally nearer the lake only lake clay is seen in the banks. The meanders are even more slightly curving, the river banks are low and there is much adjacent marshy land. Similar marshy conditions occur at mouths of all streams entering Sandusky Bay. This shows an uptilting of the lake basin to the northeast and a drowning of the mouths of the rivers entering it from the southwest.

HURON VALLEY GENERAL.

The sources of Huron River lie on the Till Plains and moraines south and east of Willard. Two main streams are thus built up, West Branch and East Branch. The river drains Huron and a part of Erie counties. The Branches flow on the Till Plains to the Maumee Beach at Monroeville and Norwalk, then on Lake Plains to Huron and Lake Erie. The branches unite about two miles about Milan.

In the upper courses the branches have low banks and narrow valleys, while near the fork the courses are meandering. The terraces are better marked above the fork, while below the fork they are trimmed off and the valley is more or less gorge-like. Near the mouth the terraces merge into an even, gentle valley slope, no well marked terraces being found. The mouth is slightly drowned as shown by marshy inlets.

A mile south of Monroeville the West Branch cuts down into Huron shale, while the East Branch does not reach shale until two miles south of the fork. Where the river is in shales steep banks are found and clay ironstone concretions stand out in the river bed like tree stumps.

The upper course of the river represents all the features of drift erosion, such as hummocky terraces, uneven banks, landslides, alluvial fans, sand bars and abandoned river channels. The middle course of the river presents youthful features such as trimmed-off terraces, gorges, rapids, large meanders, incipient cut-offs, sand bars and spits, as well as other features found in the normal erosion and denudation of sedimentary rock. The lower course of Huron River presents features of advanced youth such as semi-base-leveled terrace slope, where the lines of individual terrace fronts are obliterated and long and gentle curves in the course of the river.

Huron Valley in Detail.

East of Plymouth, West Branch wanders aimlessly westward upon the till, and has carved out for itself the shallowest of valleys. Near Plymouth it enters the Ft. Wayne moraine and has hilly topography on each side. From there the course of the stream is north. Between New Haven and Graham School the valley is V-shaped and distinctly in infancy.

At Graham School it enters the big Defiance moraine and though very crooked manages to remain in the moraine until within about four miles of Monroeville. The river cuts deeper into the drift, winds back and forth in a northwest direction in its wide drift valley as far as Greenfield School, and there turns north between drift bluffs which become less and less prominent. In this course through moraine the stream meanders well and has a typical flood plain. Finally the river flows right out upon the Lake Plain in a straight course, except for one meander, north for two miles to Standardsburg; there it begins cutting into Huron shale and cuts deeper and deeper into this shale, so that at Monroeville a rather deep gorge has been carved.

At Monroeville the stream begins typical meandering again. This time the curves are distinctly larger than in the moraine because the stream is larger. The town is mostly on a tongue in a meander loop. A half mile to the north there is a drift-filled

gorge exposed in the east side of the present gorge. Here boulders are found at the bottom of the buried valley, while its southeast side rises as a vertical bluff of Huron shale capped with till. A mile farther north in the Milan road there is a south facing scarp of Huron shale buried in drift, which shows that this filled valley may have been three-quarters of a mile wide and that its direction is probably northeast. Since it is so youthful a feature it is no doubt interglacial.

About two miles and a half southwest of the fork the gorge deepens greatly; narrow canyons are also developed in the laterals. There are no terraces. The main stream meanders back and forth across its gorge floor. Occasionally remnants of terraces are found locally defended by rock ledges, but this is unusual. It is at this point that Seymour Creek enters the West Branch. Its deep gorge is evidence of the rapid rate at which dissection of the area is going on.

The streams which unite near North Fairfield to make up East Branch have very young valleys with no terraces. From this junction, the course of the river lies just east of a north and south esker for about four miles; the banks are low and there are no terraces. The stream scarcely meanders at all.

At Macksville there are three or four terraces apparently due to normal down cutting, as farther up stream they do not exist, but gradually come into existence farther away from the river source. Below Macksville for two and a half miles the terraces are broad and the banks of the river are low. The river now turns northeast, leaving the moraine and flows across the Maumee shoreline and Lake Plain in a V-shaped valley cut in lake clays. The river becomes incised; its course more meandering than it was farther up stream and its scrolls of floodplain neatly developed. Terraces adorn the sides of the valley and meanders are rather typical. At the highway between Monroeville and Norwalk there is a broad flood plain near a meander curve. These valley forms signifying great erosion are due to the ease with which the lake clays have been eroded and carried away. The tops of the bluffs are strewn with glacial boulders and the outline of the top of the valley sides is broken by the erosion of numerous laterals.

The river proceeds northward from this meander section in a very crooked course with sharp turns; there are long narrow islands in the stream, sand bars and newly formed tiny fans.

The stream is entrenching itself. This continues to the junction with West Branch.

At the bridge a mile south of the fork, shale is seen cropping out in the river banks and the valley begins to take on the appearance of a gorge; north of here the upper part of the bluffs is hummocky and uneven in spite of the fact that it is composed of lake clays, while the lower part of the valley has the definite outlines characteristic of a bluff composed of shale. This is due to the rapid erosion of many little laterals in the clays.

East of the junction is a low area a half mile wide separated from the river by a ridge. The low strip is open at the west to East Branch and at the other end to Huron River. East Branch formerly took a turn through this area entering Huron at least a mile below the present mouth. Near the present mouth an incised meander came close to West Branch and by lateral planation the ridge between was finally cut out and the present courses established, and this low area became an abandoned channel around an isolated hill.

North of Milan the rolling gently sloping valley walls continue; the stream makes wider meanders on more marshy flood-plains; river banks become lower still and terrace fronts become obliterated. Finally at the Lake Shore road bridge at Huron, terrace fronts are no longer seen; there only remains a gradual slope from the Lake Plain above to the water course below.

Meanders are very normal and typical below Milan. They have grown in several instances to full size for such a stream and are migrating down valley trimming the bluffs and laying flood plain as they go. When a few more meanders shall have slipped down the valley the bluffs will be straighter and the meander belt will be clearly lined out.

The river mouth is drowned, as shown by ponding back of lake water for half a mile in the river. A sand bar has been thrown up by the waves part way across the mouth of the river. This is a normal thing when a rather weak stream flows into a lake with much energy.[18]

---

[18] GOLDTHWAIT, J. W. Abandoned Shorelines of Eastern Wisconsin. Wisconsin Geol. Surv. Bull. No. 17, pp. 48, 49.

GENERAL DESCRIPTION OF THE VALLEY OF VERMILION RIVER.

The Vermilion River rises from Savannah Lake at an altitude of 1,020 feet in an old valley well plugged with drift. The upper course drains Till, while the lower course drains Lake Plains, the river crossing the Maumee beach about six miles from the lake. The area drained is a strip six to eight miles wide, from the center of Ashland, through Huron and the western part of Lorain counties to Lake Erie. It is about to be pirated[19] by the West Branch of Black River, seven miles southwest of Wellington.

The important tributaries of Vermilion River are on its east side, although the river gathers the drainage for the entire basin. The East Branch rises in several heads around New London and flows northeast in a circuitous course for nine miles to a point two and a half miles north of Clarksfield, where it enters the main stream. The East fork rises from the confluence of two creeks just south of Kipton and enters the main stream fourteen miles by river course south of Lake Erie. Chance enters the Vermilion River in a deep gorge still nearer Lake Erie. The gradient of the river from the fork to the lake is lower than from the source to the fork, showing the progress of the process of maturing. The valley is oldest at its mouth but this condition of submaturity is taking possession farther and farther up stream.

Vermilion Valley in Detail.

Vermilion River drains the north end of Savannah Lake; the course of the stream is northwest in a large old rock valley, but between low lying valley slopes. The drift is very hummocky and marshy in places. There are few laterals in this part of the valley. Three or four miles southwest of New London, the old valley becomes wholly obscured by the drift. About two miles southeast of Fitchville the river bluffs become higher because the stream has cut more deeply into the drift. At Fitchville the river crosses the Defiance moraine and from here it meanders in short loops in a northeast direction nearly to the lake. Near Clarksfield there are two and in places three terraces along the bluffs. The valley floor is relatively narrow.

[19]Darton, N. H. Examples of Stream Robbing in the Catskill Mts. G. S. A. Bull., Vol. 7, 1896, pp. 505-507.

Just east of Clarksfield the river crowds close to the east side, leaving a broad, fertile flood plain on the west and a steep bluff on the east, whose upper slopes are rounded erosion forms in drift. Farther down the slopes, fans are built and hummocks carved from the easily eroded drift. Below the mouth of East Branch the terrace on the east side of the stream furnishes grounds for a sightly residence. Two large meanders and a series of small ones occur between here and Wakeman. When the valley widens, the bluff is far back from the river on one side, while on the opposite side the river usually undercuts steep drift banks.

At the highway bridge at Wakeman gray shale is seen in the river bed and part way up the banks and thus here begins the rock influence in the form of the valley. North of the dam the river valley deepens with some step terracing in the valley sides. A half mile north of Wakeman there are many small laterals which dissect the valley sides, leaving rounded promontories between them.

Three miles north of Wakeman, Berea sandstone crops out in the river bed and here the valley is steep-sided and narrow. Two and a half miles south of Birmingham the river cuts into the Bedford shale, which makes loose and crumbly banks; a half mile farther north the river reaches Cleveland shale which makes steep valley sides, great flat ledges of this fissile shale crop out in the river bed, which at low water is a bare rock flat.

From this point to within three miles of Lake Erie, Vermilion River meanders on a broad level flood plain hemmed in by gorge walls 70–80 feet high and composed of blue, black and red shales.[20] As down cutting has gone on many terraces have been made and the earlier ones have been trimmed off.[21]

Two miles south of Birmingham the East Fork enters the river from the south east in a similar deep gorge; the East Fork rises near Kipton, where two little creeks converge; their valleys are wide and spacious, because of the ease with which the drift is eroded. Chance Creek enters the main stream three and a half miles farther to the northeast; it is a boisterous stream with a rocky and rugged bed. The sides of its gorge are

[20]Dewey, Henry. Origin of Some River Gorges in Cornwall. Q. J. G. S., Vol. 72, pp. 64-66.

[21]Fisher, W. D. Terraces of the West River. Proc. Boston Soc. Nat. Hist., Vol. 33, 1906.

steep and cragged because carved in more resistant shales. Just north of the mouth of Chance Creek in the east side of the valley stands an isolated hill which is the result of the cutting off of an entrenched meander. Below this cut-off meander is another larger one not yet cut off. It has not yet been able to begin its migration down valley, but twists and turns in its own area, gradually widening its valley.

From Rugby down to the lake the bluffs decrease in height because the slope of the land is steeper than the present grade of the stream. Many meanders have developed and slipped along down the valley, planing off the bluffs until they are nearly straight parallel walls bounding the meander belt. Small terraces occasionally occur.

The swampy condition of the lower mile or two testifies again to the recent tilting of the Erie Basin; and the sand bar across the mouth of the valley, almost shutting the river out, is the evidence of the excess of power of the lake waves over the strength of stream current.

GENERAL DESCRIPTION OF THE VALLEY OF BLACK RIVER.

Black River rises in a hundred little rills that begin on the Defiance moraine between New London and Lodi at an altitude of 1,000 to 1,100 feet. West Branch gathers a score of these together near Rochester; Charleymont Creek picks up another bunch a few miles farther east and delivers their waters to West Branch north of Wellington. The East Branch gathers from the north slope of the moraine in Harrisville Township, Medina County; West Fork collects from the south side, and East Fork from Chatham township. These two forks meet, one from the west, the other from the north, near Lodi, and become East Branch. These Branches converge in a northerly direction and meet about nine miles south of Lake Erie.[22]

The upper courses are characterized by many wide valleys which look submature because of the ease with which the drift is eroded; and in some places by channels only, valleys not having been excavated yet. The middle courses are straighter with narrower valleys, due to the resistance of the Berea sandstone and the lower course is characterized by youthful features, such as a winding gorge and many terraces in the black Ohio shale.

[22]Newberry, J. S. Ohio Geol. Surv., 1878, vol. 2, pp. 206-208.

Elk Creek rises two miles west of Lagrange, flows four miles north, entering the West Branch four miles southeast of Oberlin. Wellington Creek rises a little south of Wellington and enters the West Branch three and a half miles south of Oberlin. Plum Creek rises three miles southwest of Oberlin, flows nine miles northeasterly and enters the West Branch five miles east of Oberlin.

Coon Creek enters the East Branch from the west, eight miles northwest of Lodi. On the east side the important tributaries are Crow Creek, entering eight miles, and Salt Creek, entering four miles south of Grafton. The more important tributaries are on the west side of the West Branch and on the east side of the East Branch, showing convergence of drainage toward the Elyria embayment of the Maumee and Whittlesey shorelines.

The gradient of the lower course of the river is lower than that of either branch, showing that the lower course has made greater progress. The East Branch may be considered a little older than the West Branch, as suggested by its lower gradient.

There is a temporary base level just south of the Maumee Lake ridge at La Porte[23] in the valley of the East Branch, as can be seen by its broad valley, wide meanders and low river banks. Just south of the present falls of both branches at Elyria is a second temporary base level, as seen by the low river banks of Berea sandstone and lake clays. This base level was made with reference to the level of Lake Whittlesey. A third temporary base level cannot be found, as the valley has been cut down to such a wide and deep gorge that all evidences of greater age near the Warren Lake level have been obliterated.

The West Branch of Black River works in drift until it reaches Berea sandstone four miles south of Elyria. The East Branch cuts into Cuyahoga sandstone and sandy shales at Lodi and farther north into drift; a few miles south of Grafton, Berea sandstone is reached, which serves for river bed as far as Elyria. From Elyria north with the exception of several drift filled depressions Black River cuts into Berea sandstone for two miles, then the Bedford and Ohio shales are reached. These shales are exposed in its deep gorge to the mouth of the river. The depth of the gorge decreases as the lake is approached due to the decreasing altitude of the Lake Plain.

---

[23]CARNEY, FRANK. Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab., Denison Univ., 1910, p. 102.

Valley of Black River in Detail.

East and West of Rochester, two tributaries of West Branch of Black River unite and continue to flow in a gradually broadening and deepening V-shaped valley. Other laterals converge northeast. There are no large terraces, but many small interlacing ones, and no true meanders, only irregular and abrupt turns characteristic of drift erosion. The valley at the main road west of Wellington has a submature appearance due to the ease with which the drift is eroded. A fringe of tributaries has roughened the topography for a half mile each side of the stream.

Beyond this road to Wellington the valley becomes three-quarters of a mile wide. The bluffs have Hogarth curves.[24] There are many short meanders which are entrenching themselves as evidence of the recession of Lake Erie. The flood-plains are cut up with side channels, meander cut-offs and other signs of aging. In some places uplands are very rough and hummocky and where local heaping of the drift has occurred the valley grows narrower between steep drift hills.

As the stream descends the Till Plain its bluffs become lower and about two miles northwest of Wellington it seems to emerge directly upon the Till Plain. Charleymont valley is very similar and has its shallowest part west and southwest of Wellington. Wellington Creek resembles the other branches very much. It becomes a true meandering stream about two miles above its mouth.

Just above the Wellington-Oberlin road, West Branch adopts a true meandering habit, but its meanders are very small in order to be in harmony with the size of the stream. Where the meandering habit begins the flood plain becomes distinctly broader. Five miles east of Oberlin where the stream turns north, three terraces occur, the highest being an eighth of a mile wide, and the two lower ones only a few feet in width. The high terrace or old flood plain was made with reference to a former temporary base level and now the stream is entrenching itself in its old bed.[25]

---

[24]Hicks, L. E. Some Elements of Land Sculpture. G. S. A. Bull., Vol. 4, 1893, pp. 133-146.

[25]Carney, Frank. The Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab. Denison Univ., 1910, p. 104.

For about five miles below the mouth of Wellington Creek many good meanders have been made and most of them have migrated a little downstream. For this reason several fine flood plain scrolls occur. Probably no meander in this whole section has shifted down its width, but it will not be long now until several will have done so, thus greatly straightening the course of the bluffs. About a mile below the mouth of Plum Creek a fine typical meander has been cut off. If this cut-off had not occurred so soon, in its down stream migration it would have cut through into the next turn and thus have made a typical isolated hill. The neck today is little more than wide enough for the road.

At the mouth of Plum Creek a nice network of tiny step terraces is seen, some of which coalesce at the mouth. Several other terraces occur up Plum Creek, for it has meandered well much of the way from Oberlin down. About three miles above the junction the river encounters the Berea sandstone and is straighter in its course. At Elyria the stream makes a wide meander west and north, then turns east and follows the south side of the Whittlesey Lake ridge until it meets the East Branch, its whole course here being entrenched in the sandstone.

The East Branch just north of Lodi encounters Cuyahoga shale and is influenced much more by bed rock than the West Branch. From Lodi the East Branch flows northwest in a circuitous course with dissected bluffs and narrow floodplains for about three miles. Then the valley opens out and flood plains are broader, and meanders are wider and more numerous. Between here and Grafton meanders and cut-offs can be found in almost every stage.

Three miles southeast of River Corners some of the meanders have almost cut themselves off; one meander has built out a sand bar[26] cutting off its own channel beyond the newly made sand bar next to the bluff. Sand islands are common in this section. Another meander is closing up its meander curve with a sand bar, while it continues to flow in the cut-off. In another place the meander loop has been abandoned and the stream now flows in the cut-off; the abandoned loop is easily made out by a line of trees which border this abandoned channel. At one place a fallen tree has dammed up the meander curve

[26]Tower, W. S. Development of Cutoff Meanders. Am. Geog. Soc. Bull., vol. 36, 1904, pp. 589-599.

and so a cut-off has been developed, after which the water rose so much in the meander loop that the old channel is now being carved out again and the main stream now flows in the meander curve.

In this part of the valley the bluffs are dissected and rounded at the top; at the confluence of laterals small terraces are developed with here and there small alluvial fans. Here the terraces are almost always dissected and uncertain. The great width of some of the lateral valleys might indicate the tributaries to be in valleys carved before the main valley existed; but as these laterals are not continuous on opposite sides of the main stream the great width of their valleys must be laid to the ease with which the drift can be eroded. The bluffs of laterals appear more mature, due to surface wash; all their step terraces are trimmed off, whereas in the main stream terraces have been much better preserved.

At River Corners, Black River makes a slender loop to the northeast. On the east side there are bluffs of till twenty to thirty feet high, while on the west, terraces slope back from the river. The upper terraces are rolling and dissected by laterals which have a general northward trend. The high bluffs at River Corners appear to be due to thickened drift which backs up drainage and produces a swamp or kettle just east of the stream. From the loop at River Corners the river flows straight north through a wide flood plain. From here north to Penfield there are many incipient cut-offs and cut-off meanders.[27]

From Penfield six miles northward the river has a winding course. Its meanders become very intricate. There are sharp bluffs of till where the stream makes abrupt turns. The meanders become more and more incised. From about two miles south of LaGrange to a mile north of the LaGrange road there are three steps of terraces. The second terrace front is the most prominent showing that rejuvenation in the present formation of the third terrace front has been very recent. The terrace tops are broad and even, and the terrace fronts are regular and crescentic.

About a mile north of LaGrange road the stream begins to cut its way into Berea sandstone. Step terraces cease and the river bluffs are steep and straight and close to the stream.

[27]TOWER, W. S. ibid.

Dissection is well under way as shown by two prominent laterals coming in from both sides about three-quarters of a mile southwest of Grafton. These laterals have developed little valleys in the drift. In the river itself are numerous rapids, and rectangular blocks of sandstone stand out as bold promontories at turns in the stream.

Just west of Grafton the Black River Valley is characterized by gently rolling slightly terraced bluffs. The stream flows with gentle curves in its course in a westerly direction; its bluffs are composed of alluvium above and Berea sandstone below. The river bed consists of horizontal beds of Berea sandstone jointed into blocks. The stream racing over the resistant Berea sandstone like a mountain torrent has a youthful character.

At the Oberlin Road Bridge west of Grafton where the stream has uncovered many weathered sandstone blocks in the stream bed, the valley sides are very regular, with even upper drift slopes. Thence the stream pursues a straight course northwest for two miles, where the valley, a rock gorge, is very narrow. About three miles south of Laporte the valley leaves the rock and is carved in drift, hence widens; and large meanders are found, which represent the advanced youth of the valley at the time when the East Branch of Black River entered Lake Maumee at Laporte. Just south of Laporte the stream turns east for a mile to avoid Butternut Ridge, the Maumee Shoreline. It then breaks through the ridge, where enters from the east the tributary, which also follows the base of the lake ridge. This tributary makes a wide bend to the south before entering the main stream; the bend may be explained by local heaping of the lake ridge sands. (See Oberlin Topographic Map).

North of Laporte the stream pursues a rather straight course to Elyria; river banks are low and near together, and there are many rapids in the stream bed. Some huge sandstone blocks are exposed by undercuts. The upper valley slopes are straight, regular and gentle, being composed of Maumee Lake clays.[28]

In Elyria the stream flows straight north until it makes a big meander to the east after which it turns west to avoid Middle or Whittlesey Lake Ridge. These Elyria curves of the Branches are rather symmetrical and afford an interesting crotch for the city.

[28] CARNEY, FRANK. Abandoned Shorelines of the Oberlin Quadrangle. Bull. Sci. Lab., Denison Univ., 1910, p. 102.

At Elyria both Branches of the Black River have cut back gorges in Berea sandstone for a quarter to a third of a mile from the fork. The falls of the East Branch drop over massive layers of gray drab Berea sandstone, while the falls of the West Branch are not so great and the ledges are more broken. The gorges below the falls are very steep sided with bold promontories of massive sandstone; here also are "caves," potholes, undercuts, and many big sandstone boulders.

A buried valley is found in Elyria recognized by the absence of rock and presence of drift filling in many places. On both sides the East and West Branches a little west and south of the fork respectively and across Washington Street to the East Branch above the falls these drift fills are known, locating the old valley thrice intersected by the new. In the main valley a half mile north of the fork at the children's playground, where the valley widens greatly, there may be another buried valley.

Near the fork west of the main stream is an ancient river falls with a pothole and undercutting, and other youthful features. The Bear's den is now nearly below this falls site. At the Whittlesey Lake stage the Branches of Black River emptied by separate mouths. As the lake retreated to the Warren stage the river mouths developed falls at once.[29] As the West Branch turned from paralleling the old lake ridge to fall over its former mouth northward, considerable undercutting at the turn took place. This carried the channel toward the East Branch, which it finally reached. We do not know how far the falls of the East Branch had receded at that time, but the channel where cut through must have been lower than the West Branch top of the abandoned falls or else that branch could not have been taken in; hence we assume that the falls of East Branch had retreated at least as far as the junction point, probably not much farther.

The river which flowed north over the abandoned falls was very young, and did not work there long, since the valley abandoned is not deep, but similar in character to those above the present falls in the East and West Branches.

There is a line of large Berea sandstone blocks across the valley one hundred yards below the present junction. When the lake retreated to the Warren Stage the waters of both East

[29]Dewey, Henry. Origin of Some River Gorges in Cornwall. Q. J. G. S., vol. 72, p. 66.

and West Branches made waterfalls over this rock ledge; undercutting took place so that large caves were developed beneath the falls just as are seen in the falls of West Branch today. The cave of the West Branch can still be seen at the bear den. On the East Branch a tunnel was formed by undercutting and by a small trickle working its way through a crevice and enlarging the opening. This made, of the falls, a natural bridge or sandstone arch which in no very distant past fell in, as one can infer from the massive blocks in a straight line across the valley marking the site of the old arch.

North of the line of sandstone blocks the valley widens out into a large amphitheatre with hummocky, irregular, and uneven valley sides of drift. Just north of the amphitheatre sandstone ledges reappear and the valley narrows again to a sandstone gorge a distance of about two miles.

Beyond this gorge section Black River has cut itself a much wider gorge whose bluffs are from 70–80 feet high. This gorge is cut in blue Ohio shale. Within the gorge the river meanders upon a level valley floor. The meandering habit persists practically all the rest of the distance to the lake. This meandering section illustrates several points in the history of such a stream. A node is established by the Warren Beach about four miles north of Elyria. Here the river took a large curve, much too large for a meander, to get around the beach and find a way through it.[30] This curve is so large that the river has not widened the valley much by lateral cutting, but the incised curve with its valley cut deeply in the shale has held the river from more swinging and has prevented the migration of meanders past this place.

Above this restriction the meanders during their entrenching have behaved very normally, widening as they have cut down so that two spurs or meander tongues show the long sloping tip so characteristic of such growth. Further, one meander in this part of the valley about two and a fourth miles below Elyria cut itself off long ago when the river was on a level fully thirty feet above the present, producing an isolated hill. The hill top stood some thirty feet above the cut-off of that date. The straightened stream however abandoned the cut-off and reoccupied the channel west of the hill and proceeded to erode it to

[30] GOLDTHWAIT, J. W. Abandoned Shorelines of Eastern Wisconsin. Wisc. Geol. Surv. Bull. No. 17, p. 48.

the present level. During the down cutting the meanders grew each side of the hill and now they threaten to cut through again where the old cut-off occurred.

The flood plain crescents in this section are very typical. Terraces occur at two or three places.

In this section for three miles below the Warren Beach or as far as the big turn westward into Lorain, the meanders, six or eight in number, are slowly slipping down stream in a very interesting and typical fashion. Four miles southeast of Lorain the river turns sharply to the west and takes a winding course in that direction to its mouth. There is considerable drowning near the mouth, as seen by numerous marshes, and ponding back of water in side streams. The steel company has dredged out a large turning basin for ore boats near their docks.

GENERAL DESCRIPTION OF ROCKY RIVER VALLEY.

Rocky River is the only one of the five streams studied that really heads back in the Allegheny Plateau province, although Vermilion for a few miles below Savannah Lakes, and East Branch of Black River near Lodi both flow in large, old, preglacial valleys.

The West Branch of Rocky River has sources in the plateau near Boneta at altitudes 1,100 to 1,200 feet. The East Branch has many sources in Royalton and Richfield townships in northwestern Summit County, some of which are over 1,300 feet above sea level. The main stream begins a mile north of North Royalton and flows eight miles southeast in an old valley of the plateau, then turns abruptly, enters another similar but larger preglacial rock valley and flows northwest an equal distance without getting anywhere over two miles from the portion flowing in the opposite direction.

Rocky River exhibits the phenomenon of bifurcation just below the earliest Maumee shoreline at Olmstead, and, as was the case with Huron and Black rivers, formerly flowed into Lake Maumee as two separate rivers. The important tributaries enter from opposite sides of the drainage basin and the adjacent sides of the Branches have few tributaries, in harmony with the interpretation that the two Branches entered the lake in the same very old preglacial valley at an embayment of the lake.

The temporary base level of the Maumee shoreline is found recorded in many characteristics of advanced youth north of the falls of the East Branch and about two miles to the south of the fork. The lower temporary base levels are scarcely discernible on Rocky River.

Description of Rocky River in Detail.

West of Boneta the north side of the valley has numerous step terraces above which rises a gentle slope northward to the top of a knob at an altitude of 1,204 feet. The course of the river northwest is irregular, due to the blocking effect of the drift. In this part of the course of the river the laterals come in from almost any direction, because of uneven distribution of drift over the old rock topography. Barbed tributaries do not indicate captures. Terraces are few; the valley is V-shaped, with rolling hills of drift on either side. A mile southeast of the Medina-Cleveland road the flood plain widens for several miles and carries above it terraces with rounded fronts. The town of Liverpool is on a broad flood plain on the west side of the river. From here north to Hardscrabble the river meanders in an ever deepening and widening gorge. Its flood plain is broad and level. A half mile north of Copopa the river has incised its banks and the higher terraces are straight and regular. Between Hardscrabble and Copopa and beyond, the meanders are numerous and well developed. They have migrated freely down stream, trimmed the bluffs until this section has a marked meander belt. A mile below Hardscrabble, a meander has cut itself off and left an isolated hill.

A mile above Westview the river begins cutting into the hard Berea sandstone and so has a valley a great deal narrower, with bluffs steeper and straighter. There are many rock ledges protruding from the river banks; at turns in the river huge rocks stick out. From here north to Olmsted Falls the gorge becomes deeper, straighter and narrower; there are no terraces for the bluffs are close to the stream.

A mile and a half north of Olmsted Falls the river works its way into shale; the bluffs are not so steep as before, because composed of crumbly shale; there are a considerable number of terraces at many points. The river continues in these black shales to the lake. Bluffs vary from strikingly youthful ones to sub-mature, depending upon the time since the river has been

undercutting them. Large laterals through headward erosion have cut their way back into the shale and made ravines deep for side valleys. Such laterals are more numerous on the west side of the valley showing the convergence of drainage toward the Rocky River embayment. The laterals have upper rounded promontories between them and tiny valley systems all their own as evidence of progressive dissection of the area. The main stream is very active, due to the high gradient which is more than ten feet per mile in this part of the river. In the flood plain are often found abandoned channels littered with rock debris as evidence of recent floods.

Immediately northeast of Olmsted there are two isolated hills which are a quarter of a mile in length and perhaps a little less than that in width; their long axes are northeast. (See Berea Topographic Map). The East and West Branches of Rocky River now meet at Cedar Point; a sharp cusp-like bluff of bluish gray shale. At one time the two branches of Rocky River met just north of the north isolated hill. This may be seen by the relatively more mature appearance of the valley to the northwest of north hill than the present valley of the West Branch just west of Cedar Point. It may be shown also that the Branches met here before they met just east of the south hill because the valley north of the north hill has a floor a few feet higher than the floor of the valley east of the south hill, but sloping down stream and the bluffs are more mature in the former valley than in the latter.

It may be seen that the West Branch flowed south in the valley east of the south hill and that the East Branch did not flow north in this valley because the valley northwest of the north hill is a few feet higher than the valley east of the south hill.

The making of the valley between the hills may be explained by undercutting of both branches as they swing toward each other until they cut through and allowed West Branch to enter the other. It then followed East Branch and abandoned its course around north hill because East Branch had the lower valley floor. In a similar way meander curves in the branches undercut towards each other until they met between Cedar Point and south hill. West Branch went into East as before because it there had a lower course. Examine the bluffs of the valleys and sides of the hills to see how their curves and relative steepnesses all conspire to support this explanation for the hills.

East Branch of Rocky River in its upper five miles has no terraces and the bluffs merge imperceptibly into the upland slopes. Probably the stream has not greatly modified the valley since the glaciers left it.

West of West Richfield the valley deepens and has in its lower part a steeper V-shaped profile. The river flows south here to conform to preglacial rock topography which is well mantled with drift. In Southeast Hinckley township it turns west and northwest around the base of a rock hill and enters a preglacial valley which it follows nearly to Berea. It usually exposes drift but occasionally encounters rock. The stream pursues a northwest course in an ever broadening valley with even, gentle upper slopes, the drift mantled bluffs of the preglacial rock valley. This old valley leads east of the town of Berea and is occupied by Abram's swamp and creek to the Big Four tracks, where Gould found a well boring two hundred feet to rock.

Baldwin Creek in its lower course crosses this buried valley which explains its greater width and well developed flood plain in its last mile. Just north of Strongsville the valley is unusually wide, showing the presence of the drift buried valley.[31] In this section to Berea the stream has many small meanders which have migrated down stream planing off the valley walls and widening the flood plain. There are numerous back channels, flood channels and curves with incipient cut-offs. Some of the meander loops are very short and turn back upon themselves around neat meander tongues. The flood plain is very level. The stream is working in drift and Cuyahoga shales.

Through Berea the Branch is in a rock gorge of Berea sandstone, narrow, rugged, youthful and, south of town, much defaced by quarrying operations.

Just north of the town the stream cascades over Berea sandstone making a high waterfall below which the gorge is deep and rugged, with bold promontories of sandstone, caves and undercutting, while the stream bed has potholes and rapids.

A half mile north of the falls, sandstone is no longer seen in the gorge side; instead Bedford and Ohio shales crop out. A

[31]Newberry, J. S. Geological Survey of Ohio, Vol. 1, pp. 171 and 172.
Leverett, Frank. Glacial Formations of Erie and Ohio Basins. Monog. 41, U. S. G. S., p. 617.

tiny alluvial fan in one place, composed of Bedford shale waste, rests upon the darker blue Ohio shale. Three small drift sections in the valley walls within a short distance below Berea indicate buried valleys.

In about two miles (bee line) above the confluence of the branches, East Branch has eight good meanders. As they developed they became entrenched and began migrating down stream. None has yet moved its width, but most of them have slipped partly out of their initial curves.

On the east side of the stream are many tiny parallel channels the precursors of a fringe of lateral valleys like those on the east side of Abram Creek. Here is also a deserted flood plain or terrace, higher than the present flood plain. On this terrace is a fan which gives a clue to the age of the present flood plain, because the amount of time represented in the making of the fan would not exceed that which the stream took in the cutting of its present channel and the making of the lower flood plain.

Below the isolated hills the valley widens and frequent step terraces have been carved. Abram Creek enters the main stream a mile below the fork in a rocky gorge. Two miles up stream a meander in East Branch threatened to capture Abram's but turned aside in time to avoid the piracy. Two miles south of the Lorain Street bridge a small tributary on the east side enters the main valley headed upstream. It must have had to dodge a subordinate ridge of the Maumee shoreline before entering the lake; then when the lake fell, the river came and took it in. The main stream is now endeavoring to take this tributary in, nearly one half mile above its present mouth. It would then be a splendid hanging valley, with an abandoned valley behind an isolated hill.

Just south of the Lorain Street bridge in the main valley, there is a long isolated hill fifty feet high, composed of drift; to the east are three ravines leading into the abandoned valley behind the hill. It seems probable that the main stream once ran east of this hill and swung west in two meanders, one before going behind, the other after. Subsequently these meanders cut into each other and the river left the course east of the hill for one west. Drift is exposed in the ravine farthest to the south, shale and drift in the middle ravine and drift in the ravine farthest to the north. This whole problem is worked out in a buried valley, probably the one occupied by Abram

Creek farther south. The buried valley is known on the west side from here to the lake. The shale in the middle ravine points to an isolated hill in the old drift-buried valley. The mouth of this buried valley, Newberry found at Kings Camp, two miles west of the present mouth of Rocky River.

Summarized, these several notes on the buried valley, it may be stated that an old preglacial valley partly filled with drift from southeast of Hinckley almost to Berea is occupied by East Branch. In places the stream touches the old rock walls. The buried valley leads almost straight north, across the lower mile or so of Baldwin Creek, east of Berea, and the Fairground, through Abram swamp and creek, to the Big Four tracks, then, on north without a stream until it is crossed by Rocky River just above Lorain Street. From here it leads to the lake on the west side of the present Rocky River.

For a mile north of the Lorain Street bridge, Rocky River has a broad level flood plain lying at the bottom of a ninety foot shale gorge, but at the end of the mile, the valley becomes very narrow and the river turns west around a big loop, then east again and north. The large loop is not a true meander, but is due to the effort of the stream to get through the old Whittlesey Beach. At the west end of this loop the bluffs as well as those of the little laterals entering here, are of drift. This is the evidence that Newberry cited of a continuation of the large buried preglacial valley "two miles above its mouth." Undercutting at the east end of this large loop may easily produce an isolated hill.

North of the meander the river flows straight north for a half mile; here the shale banks are moderately steep. The river swings first to one, and then to the other side of its narrow floodplain. The floodplain appears to the observer at the top of the gorge as long slender ovate beads strung on the blue ribbon of the river.

A mile south of the lake shore road bridge the river meanders to the west and then flows straight north where the gorge is wider and deeper; the precipitous gorge walls are composed of grayish blue shale.

At the lake shore road bridge the river has carved out for itself a steep sided gorge whose walls are composed of grayish, drab, fissile shale, very thinly bedded. Just north of the bridge there is a sandbar whose long axis is parallel with the river course; this bar is composed of reddish alluvium.

At the very mouth of the river, jutting out from the east bank is a double hooked spit, built by alternate deposition by river current, northeast lake wash and west shore current.

On each side of the mouth stand high promontories, (bold "sea Cliffs") of Ohio shale, showing below, a lower concave elongated curve of water erosion, and above, a rounded convex curve of subaerial erosion.[32] The lower curve is the more prominent, so that these bluffs stand out in strong relief silhouetted against the morning sky.

Discussion.

There are some significant features in the physiography of these river valleys that need fuller explanation than has been given them in the descriptive matter. Let us first turn to buried valleys. Buried valleys are not of unusual occurrence in glaciated areas.

There are two kinds of buried valleys, those with gentle mature sides and those with steep bluffs. The latter may be gorges excavated in an interglacial period or immediately before the Glacial period, when the ice dammed up the lower parts of the valleys and drainage was forced to reverse and go over the divides. The former are broad, mature to old valleys of really Pre-Pleistocene time.

In the area under discussion buried valleys are found in several places on the Sandusky River between Tiffin and Fremont, one at Fremont, one in the Huron River a mile north of Monroeville, one at Beaver Creek two miles south of Lake Erie, one in the fork of the Black River at Elyria, and one in the lower part of the Rocky River, whose mouth is at Kings Camp, two miles west of the mouth of the present Rocky River. These seem to be almost if not entirely of the gorge type.

It should be noted that the last buried valley mentioned is not of the gorge type in its upper part. Certainly at the lake it is relatively narrow. Above the Lorain Street bridge it is probably no wider than the present valley and possibly as steep-sided. It is so completely covered from here south to Berea that its character is not discernible, but above Berea no gorge type is known. East Branch flows in its own little valley far down in the large advanced mature rock valley, which leads

[32]Gilbert, G. K. Topographic Features of Lake Shores. Fifth Ann. Rept. U. S. Geol. Surv., p. 83.

from Hinckley township to Binola at least. Whether there is a gorge section continuing south of Berea somewhere is not known. We have found no evidence of it.

The buried valley exposed in the Huron River north of Monroeville and the one exposed in Beaver Creek two miles south of Lake Erie show steep buried escarpments of Ohio shale. These gorges must have been carved out by streams which were rejuvenated upon the retreat of the ice in an interglacial period. These valleys could not have been preglacial, because at that time the surface was carved into broad open valleys. Probably most of the buried valleys in the area studied where there is an abrupt discontinuation of bedrock, are valleys of this type. These gorges were cut in large old preglacial valleys or across divides from one valley to another.

Evidences for the wide preglacial valleys are found in the embayments or the drainage systems which converge toward older lake embayments represented by large curves in the abandoned lake ridges; further buried valleys are actually found in these drainage basins. Old rock hills with slopes of 2–3 degrees are found in many places in our area. These are the higher lands between the valleys or the walls of the very mature, buried, Pre-Pleistocene valleys. Such hills barely protrude now through the drift. One may be seen one and one-half miles south of Berlin Heights, another across East Fork-Vermilion north eastward from Kipton. In the summits of several of them quarries for the sandstone have been opened.

A second topic for discussion is that of river terraces. Terraces in our area are not as well pronounced or as common as might be supposed. In the first place in the lower part of the river courses where terraces were formed, the development of gorges and migration of meanders have trimmed off most of them. In the second place, in the upper part of the river courses where terraces have developed, the loose texture of the drift of which they are composed offers no resistance to surface drainage, so that soon the terrace fronts are dissected and finally the whole becomes a gentle valley slope.

That the absence of terraces in the lower courses of the rivers is due to terrace trimming by the stream through its lateral and down stream shifting is shown by the presence of fragments of terraces that do remain in the lower courses of the river, on the side of the valley opposite from which the stream now flows.

Cases in point are the terraces of Ballville and of Rocky River just south of Cedar Point on the east side of the West Branch. Another evidence of the terrace trimming is the presence of remnant terraces capping overhanging undercut bluffs. The next flood season may find the stream on the opposite side of its valley undercutting terraces that now seem perfectly safe. Many examples of this process can be found anywhere in the valleys on a much smaller scale.

While many of the terraces here cited are due wholly to normal down cutting as seen by absence of terraces near the river mouths and by the present process of down cutting, not a few, indeed, may be due to an interrupted erosion cycle. Examples of such terraces are found in many places just south of the old lake shorelines where the rivers are now entrenching themselves because of further rejuvenation on account of the further lowering of the lake level. These terraces have rolling uneven tops and are sub-mature in appearance.

A third topic of interest is the correlation of valley type with character of rock. There are four types of valleys in the area; the shallow limestone valley, the shale gorge, the V-shaped drift valley and the sandstone valley.

The stream bed of the limestone valley is rough, jagged, rocky and corrugated. The river banks are low and craggy with numerous undercuts; potholes are an important feature of the river bed. The flood plains are broad and undulating; there are a few narrow rock terraces, but generally the bluff rises from the flood plain with a gradual slope to the lake plains above. The rivers of limestone valleys have straighter courses and lower banks than those in the other types of valley. The shallowness of the valleys is primarily due to the general lower level of the land.

The shale gorge as exemplified in the gorges of Huron and Vermilion, Black, and the lower part of Rocky has high vertical bluffs. From the uplands the valley is not noticed until its very edge is reached. The gorge floor is usually wide near the mouths of the streams. The streams meander back and forth from one side of the winding gorge to the other. All the phenomena of the erosion of soft sedimentary strata are found, such as fans, fan deltas, sand bars, small alluvial plains, little islands, meanders and meander cutoffs.

The V-shaped drift valley is in direct contrast to the foregoing types. Its valley sides are very hummocky; interlacing terraces, small rounded promontories and heaps of glacial drift are other features of the valley side. The course of the stream has an irregular outline with sharp turns and local rapids and dams of glacial boulders. The river banks are usually low and composed of glacial drift or gravels. The flood plains are uneven and are cut by many little meanders and irregular turns of the main stream. Occasionally the valley sides are far back from the stream. The graceful Hogarth curve is often displayed in these valley sides where surface erosion has smoothed off their tops.

The sandstone valley is similar in character to the shale gorge. Where down-cutting has gone on for considerable time the bluffs are steep, with deep craggy gorges; where down-cutting has not proceeded so long, low rocky banks, wide flood plains and graceful upper slopes are features of the valley. Bold craggy promontories on a small scale are distinguishing features of the landscape. The reason for differences in the types of these valleys may be found in the way in which the rock resists erosion. Limestone is affected largely through solution, shale is weakest along joint planes, drift due to its loose texture is very readily carried away, while sandstone, very resistant toward solution, is weakest toward mechanical agents of erosion.

Another physiographic feature of interest is the isolated hill. Three have been described in Rocky River gorge, three in the upper course of Sandusky River valley, while there is one of prominence in the lower course of Vermilion River gorge, just north of where Chance Creek enters the main stream, and a small one at the fork in Huron River valley.

Isolated hills may originate in several ways; they may arise simply as islands by the formation of meander cut-offs when the stream has entrenched itself; or they may be the result of undercutting on adjacent sides of two meander loops in an already deeply incised gorge. They may originate at the confluence of two streams when either or both undercut toward each other and so meet farther up stream. Examples of this mode of origin are found in the isolated hills at Cedar Point and in the isolated hill at the fork of Huron River. Another type of origin of the isolated hill may be found in the work of a small lateral in combination with that of the main stream; a

case of this type is that of the small stream coming into Rocky River headed up stream, midway between Lorain Street bridge and the confluence of the branches. The isolation is not quite completed yet.

A good example of the isolated hill derived from the entrenching of a meander cut-off is found in one just north of the mouth of Chance Creek in the lower Vermilion gorge where behind the hill is the outline of the old meander, while the present stream flows in the cut-off.

Another physiographic feature of interest is the parallelism of drainage basins in a part of our area, and the convergence of many of the tributaries toward shore lines of former lake embayments. The former occur where the abandoned pro-glacial lake plains descend rather uniformly to the present lake. The latter by contrast, are found where there were Tertiary Valleys, which were tributary to axial Erie Valley and, in spite of ice erosion and deposition, which still persist strong enough to make embayments in successive abandoned shorelines, and to direct the post-glacial drainage towards their own axes.

Summary Conclusions.

1. The rivers of the area studied are consequent streams upon the till plain, initial upon the retreat of the glaciers, increasing in length at their mouths as the ice withdrew, flowing north from the morainic divide into successive pro-glacial lakes.
2. The direction of the streams has been determined by:
    - (a) General northward slope of the Till Plain in Lake Erie Basin as caused by either:
        - (1) Pre-glacial erosion resulting in very mature valleys parallel to each other and tributary to axial Erie Valley, as a part of the great Tertiary valley system of the Great Lakes region, or in base leveled inter-stream areas down which parallel streams now flow.
        - (2) Crustal downwarping of the Erie Basin.
        - (3) Depression due to the weight of the ice.
    - (b) Till Plain irregularities, such as moraines, kettles, knobs, and eskers.
    - (c) Uncovering of buried valleys.

(d) Blocking effect of present and former lake beaches, causing streams to parallel the lake shore for a distance before their embouchure.

3. Gorges, waterfalls, rapids, incised meanders and high terraces are due to repeated rejuvenation of the streams caused by progressive retreating of Pro-glacial Lake Erie through Maumee, Whittlesey, Warren and other stages.
4. The advanced youth of some of the valleys just south of the old shore lines indicates temporary stability of base level in the successive pro-glacial lakes when the rivers worked at grade near their mouths.
5. There are distinct types of valleys whose physiographic features owe their variety to the character of the rock eroded. The types of valley are the shallow limestone valley, the shale gorge, the V-shaped drift valley and the sandstone valley.
6. Vigorous dissection and denudation of the area is in progress.
   (a) The tributaries of the main stream have a dendritic pattern because slightly modified by irregularities in the drift, such as kettles, knobs and eskers and old shore lines.
   (b) Consequent drainage of the immediate lake slope is vigorous.
   (c) Miniature peneplanation is shown in many valley gorges where isolated hills rise as monadnocks from the valley floor.
   (d) Through headward erosion of the main streams higher gradients have moved farther up stream and the low gradients of the mouth sections have extended in some cases many miles upstream.
7. Convergence of drainage in Huron, Black and Rocky River drainage basins is due to very old preglacial valleys partly obscured by drift.

THE CHICORY FAMILY IN OHIO.*

NELLIE F. HENDERSON.

CICHORIACEÆ, Chicory Family.

Mostly herbs, almost always with milky sap, alternate or basal leaves and ligulate flowers in involucrate heads. Bracts of the involucre in one to several series. Flowers bisporangiate, epigynous, sympetalous, tetracyclic, pentamerous, zygomorphic; calyx reduced to mere scales, or simple or plumose bristles, or wanting; ovulary unilocular with one anatropous ovule, style slender with two stigmas; stamens united with the corolla, synantherous. Fruit an achene.

PHYLETIC SYNOPSIS.

I. Pappus of chaffy scales.
  (1) Cichorium.
II. Pappus none.
  (2) Lapsana; (3) Arnoseris.
III. Pappus of both scales and bristles.
  (4) Krigia; (5) Cynthia.
IV. Pappus plumose.
  A. Receptacle chaffy.
    (6) Hypochaeris.
  B. Receptacle naked.
    (7) Picris; (8) Apargia; (9) Tragopogon.
V. Pappus of capillary bristles.
  A. Achenes not spinulose above.
    1. Achenes nearly terete.
      (10) Hieracium; (11) Crepis; (12) Nabalus; (13) Sitilias.
    2. Achenes flattened.
      (14) Sonchus; (15) Lactuca.
  B. Achenes spinulose above.
    (16) Leontodon.

KEY TO THE GENERA.

1. Pappus none.........2
1. Pappus of scales or bristles, or both present.........3
2. Erect branching herbs; peduncles short and slender.........*Lapsana.* (2)
2. Scapose herbs; peduncles very long, thickened gradually to the head. *Arnoseris.* (3)
3. Pappus of stiff scales with or without an inner series of stiff bristles.........4
3. Pappus of simple or plumose bristles.........6
4. Flowers blue, violet, or white; pappus scales blunt; branching herbs. *Cichorium.* (1)
4. Flowers yellow or orange.........5
5. Pappus scales 5, obovate or rounded, and 10 or more slender bristles. *Krigia.* (4)
5. Pappus scales 10–15, linear to oblong, minute, with an equal or greater number of capillary bristles.........*Cynthia.* (5)

---

* Papers from the Department of Botany, Ohio State University, No. 152.

6. Receptacle chaffy, flowers yellow, pappus plumose; more or less scapose herbs.. *Hypochaeris.* (6)
6. Receptacle naked, faviolate, or short fimbrillate..............................7
7. Pappus of plumose bristles..8
7. Pappus of simple bristles with or without some soft white scales...........10
8. Leaves linear-lanceolate, glabrous........................*Tragopogon.* (9)
8. Leaves toothed or lobed; plants more or less hairy, or if not, then decidedly scapose..9
9. Leafy-stemmed, hispid; several or numerous heads..............*Picris.* (7)
9. Scapose; single heads, or if more, then plants glabrous or nearly so. *Apargia.* (8)
10. Acaulescent, with naked hollow scapes and large solitary heads; fruit very slender, beaked..................................*Leonotodon.* (16)
10. Leafy-stemmed, branched; very rarely scapose but not as above..........11
11. Pappus bristles surrounded by a villous white ring at base; ours glabrous or nearly so.......................................*Sitilias.* (13)
11. Pappus bristles not surrounded by a villous ring..........................12
12. Ovularies and achenes cylindrical or nearly so............................13
12. Ovularies and achenes flattened...15
13. Heads narrow, cylindrical, few-flowered, usually dropping; flowers white, cream, or purple.......................................*Nabalus.* (12)
13. Heads broad, flat, erect; flowers yellow, orange, or red..................14
14. Pappus of very slender white bristles; involucre of one series of equal bracts; achenes beakless, narrowed at the base..............*Crepis.* (11)
14. Pappus of very stiff, persistent, brown or brownish bristles; 1–3 series of bracts in the involucre; achenes oblong................*Hieracium.* (10)
15. Involucres cylindrical; flower heads less than ½ in. broad; flowers white, blue, or yellow...*Lactuca.* (15)
15. Involucres ovoid or campanulate; flower heads ¾–2 in. broad; flowers all yellow..*Sonchus.* (14)

1. *Cichòrium* (Tourn.) L.

Branching herbs with blue or white flowers. Involucral bracts in 2 series, the outer spreading, the inner erect. Receptacle flat, naked or slightly fimbrillate. Pappus of 2 or 3 series of blunt chaffy scales.

Cichorium intybus L. Chicory. Stiff, much branched, slightly hispid perennials, from a fleshy tap-root, 1–3 ft. tall. Heads usually sessile in clusters of 1–4, showy, 1–1½ in. broad. Leaves spatulate, narrowed into long petioles, dentate or lobed, 3–6 in. long; the upper ones smaller, lanceolate to oblong, lobed or entire, clasping. The root is used as an adulterant of coffee. Roadsides and waste places. June–Oct. Rather general. Naturalized from Europe.

2. *Lâpsana* L.

Heads of yellow flowers borne on short slender peduncles. Involucre cylindrical, with 1 series of equal principal bracts. Receptacle flat and naked. Achenes obovate to oblong, somewhat flattened. Pappus none.

Lapsasa commùnis L. Nipplewort. Erect branching annuals, 1–3½ ft. tall. Lower leaves ovate, somewhat lyrate, obtuse, dentate, petioled; upper ones smaller, oblong to lanceolate, acute, sessile, sometimes entire. Heads panicled, numerous, ¼–½ in. broad. Naturalized from Europe. Roadsides and waste places. June–Sept. Franklin and Lake Counties.

3. *Arnóseris* Gærtn.

Herbs with several or numerous scapes from one root, glabrous or nearly so. Involucre campanulate, bracts in 1 series, keeled after flowering. Receptacle flat, pitted, not chaffy. Pappus none. Achenes oval.

Arnoseris mínima (L.) Dumort. Lamb Succory. Simple or branched annuals, 3–12 in. tall, with 1–4 branches. Peduncles long, thickened gradually to the head, hollow below the head. Leaves all basal, oblanceolate or spatulate, toothed. Heads ⅝ in. or less broad. Flowers yellow. Adventive from Europe. Fields and waste ground. Summer. Lake Co.

4. *Krígia* Schreb.

Herbs with yellow or orange flowers. Involucre campanulate, with 9–18 principal bracts in 2 series, reflexed in fruit. Receptacle flat, naked. Pappus of 5 obovate or rounded scales and 10 or more simple bristles. Achenes turbinate, truncate.

Krigia virgínica (L.) Willd. Carolina Dwarf-dandelion. Acaulescent annuals with several scapes from one root, sometimes branched near the base, 1–15 in. tall. Leaves usually all basal, lyrate, rarely, entire, spatulate, narrowed into margined petioles. Heads ¼–¾ in. broad. Dry sandy soil. April–Aug. No specimens.

5. *Cynthia* D. Don.

Herbs with yellow flowers. Involucre campanulate, with 9–18 principal bracts in 1 or 2 series with no short outer ones, lanceolate, not keeled, reflexed in fruit. Pappus of scales and bristles. Achenes oblong.

Cynthia virgínica (L.) D. Don. Virginia Cynthia. Glabrous, glaucous perennials, 1–2½ ft. tall, branched above, with 1–6 long-peduncled heads. One clasping leaf below the middle; basal leaves tufted, spatulate or lyrate, toothed or entire, narrowed into margined petioles. Heads 1½ in. broad. Pappus of 10–15 small scales, linear to oblong, and as many or more capillary bristles. Moist open woods and meadows. May–Oct. General.

6. *Hypochaèris* (Vaill.) L.

More or less scapose herbs with yellow flowers on a chaffy receptacle. Involucre cylindric to campanulate; principal bracts in several series. Pappus plumose. Achenes rough, long, slender, pointed.

Hypochæris radicàta L. Long-toothed Cat's-ear. Slender stemmed, glabrous perennials, 1–2 ft. tall, with several stems from one root, usually bracted. Basal leaves spreading, obovate to oblanceolate, dentate to pinnatifid, hirsute. Heads flat, 1 in. or more broad. Native of Eurasia. In waste places. May-Oct. Lake, Ashtabula, Wayne.

7. *Pìcris* L.

Leafy-stemmed, hispid herbs with spreading corymbose or paniculate clusters of flower heads. Involucre campanulate; principal bracts in 1 series with outer ones spreading. Pappus of plumose bristles. Achenes transversely wrinkled.

1. Outer involucral bracts linear............................*P. hieracioides*
1. Outer involucral bracts foliaceous............................*P. echioides*

Picris hieracioides L. Hawkweed picris. Much branched biennial, 1–3 ft. tall. Leaves lanceolate to oblong-lanceolate, irregularly toothed, narrowed to the petiole; stem leaves few and small, sessile. Heads numerous, ½–1 in. broad. Outer involucral bracts linear to linear-lanceolate. Flowers yellow. Achenes short-beaked. Waste places. Adventive from Europe. June-Oct. No specimens.

Picris echioides L. Bugloss Picris. Branched annual or biennial about 2½ ft. tall. Basal leaves spatulate, 2–6 in. long, narrowed into petioles; upper ones smaller, ovate to lanceolate, sessile or clasping. Heads numerous, short peduncled, ½ in. broad. Outer bracts of the involucre foliaceous, inner ones membranous. Flowers yellow, Pappus densely plumose. Adventive from Europe. Waste places. July–Sept. Carroll County.

8. *Apárgia* Scop.

Scapose perennials with a tuft of basal leaves, mostly pinnatifid. Involucre ovoid. Receptacle flat, fimbrillate, villous or somewhat honeycombed. Pappus of plumose bristles. Achenes oblong to linear, beaked at the top.

1. Scape scaly; pappus of equal plumose bristles................*A. autumnale*
1. Scape not scaly; pappus of two types, or of two unequal series..............2
2. Pappus of the outer flowers scales, of the inner ones plumose bristles, *A. nudicaulis*
2. Pappus of an outer series of short and an inner series of plumose bristles, the same in all flowers..*A. hispida*

Apargia autumnàle (L.) Hoffm. Fall Hawkbit. Nearly glabrous, scapes usually forked and scaly, ½–2 ft. tall. Leaves narrow, oblong to linear-lanceolate, 3–8 in. long, toothed or pinnatifid. Heads 1–1¼ in. broad. Flowers yellow. Pappus tawny, equal, plumose. Achenes with short beak. Fields and roadsides. Naturalized from Europe. June–Nov. No specimens.

Apargia nudicaùlis (L.) Britt. Rough Hawkbit. More or less hirsute, scapes slender, simple, 4–12 in. tall. Leaves linear-oblong to spatulate, hispid, narrowed into petioles, 2–5 in. long. Heads solitary, ⅜–⅝ in. broad. Involucre pubescent, bracts lanceolate. Outer flowers with scaly pappus, inner ones with plumose bristles. Waste places. Adventive from Europe. June–Oct. Lake County.

Apargia híspida (L.) Willd. Common Hawkbit. Bristly hispid or glabrous stems, bractless, ⅓–2 ft. tall. Heads nodding before flowering. Leaves oblong-lanceolate, coarsely dentate or pinnatifid. Heads 1½ in. broad or less. Pappus of an outer series of short and an inner series of long plumose bristles, alike in all flowers. Fields and waste places. July–Sept. No specimens.

9. *Tragopògon* (Tourn.) L.

Much branched succulent herbs. Leaves linear-lanceolate, clasping, glabrous. Bracts of the involucre in 1 series, nearly equal, acuminate. Pappus of 1 series of plumose bristles, inter-webbed. Achenes terete or 5-angled, linear.

1. Flowers yellow, bracts rarely longer than the flowers..........*T. pratensis*
1. Flowers purple, bracts much longer than the flowers..........*T. porrifolius*

Tragopogon pratênsis L. Yellow Goat's-beard. Branching perennial, 1–3 ft. tall. Leaves sometimes 10 in. long, keeled, clasping, long acuminate. Heads 1–2½ in. broad. Bracts lanceolate, acuminate, about 8 in number, rarely exceeding the yellow rays. In fields and waste places. May–Oct. Lake, Erie, Fulton, Auglaize, Franklin, Miami.

Tragopogon porrifòlius L. Salsify. Erect, branching, from a thick root, sometimes 4½ ft. tall. Leaves lanceolate, long acuminate, clasping. Heads 2–4 in. broad, showy. Peduncles thickened and hollow below the heads. Bracts usually much longer than the purple flowers. Fruit sometimes 2 in. long. Fields and waste places. May–Oct. Rather general.

10. *Hieràcium* (Tourn.) L.

Perennials wirh orange, red, or yellow flowers. Heads broad, flat, erect. Involucral bracts in 2 or 3 series. Pappus of very stiff, persistent, brown or brownish bristles. Achenes terete or 4–5-angled, not beaked.

1. Lower stem abundantly leafy.....2
1. Scapose or with 1–3 leaves on the stem near the base.....6
2. Principal bracts of the involucre in two or three series; leaves numerous, short..... *H. canadense*
2. Principal bracts of the involucre in one series.....3
3. Leaves lanceolate to lanceolate-oblong, acute or acuminate; panicle spreading, stem glabrous or pubescent below..... *H. paniculatum*
3. Leaves obovate, oblong, or broadly spatulate, mostly obtuse; stem hispid or glandular.....4
4. Panicles leafy-bracted; achenes truncate.....5
4. Panicles not leafy-bracted; achenes spindle-shaped..... *H. gronovii*
5. Involucre glabrous or nearly so; leaves glabrous above, hairy on veins beneath..... *H. marianum*
5. Involucre glandular; leaves hairy on both sides..... *H. scabrum*
6. Stem scapose with two or rarely two or four heads; heads one in. or more broad; stoloniferous..... *H. pilosella*
6. Stems leafless or with one or two leaves near the base; heads corymbose or paniculate, less than one in. broad.....7
7. Principal bracts of the involucre in two or three series; plants stoloniferous.....8
7. Principal bracts of the involucre in one series; not stoleniferous.....9
8. Flowers reddish-orange; stolons numerous..... *H. aurantiacum*
8. Flowers yellow; stolons few..... *H. pratense*
9. Involucre and stems glabrous or nearly so; leaves usually purple-veined, spreading on the ground..... *H. venosum*
9. Involucres and peduncles hairy and glandular, lower stem glabrous; leaves green, ascending..... *H. greenii*

Hieracium canadênse Mx. Canada Hawkweed. Plants leafy-stemmed pubescent or glabrate, 1–5 ft. tall. Leaves numerous, ovate to oblong-lanceolate, acute or acuminate; upper ones rounded or subcordate, sessile or clasping at the base; lower somewhat spatulate, or toothed; no rosette of basal leaves at flowering time. Several to many heads in a corymb. Heads 1 in. broad; 2 or 3 series of bracts in the involucre. Achenes truncate. Woods and thickets. July–Sept. Erie and Cuyahoga.

Hieracium paniculàtum L. Panicled Hawkweed. Slender, erect, leafy-stemmed herbs, 1–3 ft. tall, glabrous except at the base. Leaves thin, lanceolate, remotely toothed, acute, glabrous, narrowed at the base; upper ones sessile, lower ones may be petioled. Heads in panicle

with widely divergent peduncles. Heads 12–20-flowered; involucre of 1 principal series of usually glabrous bracts. Achenes truncate. In dry open woods. July–Sept. Hamilton, Cuyahoga, Wayne, Richland, Fairfield, Monroe.

Hieracium gronòvii L. Gronovius' Hawkweed. Slender, stiff, leafy-stemmed herbs, sometimes nearly leafless, villous near the base, 1–3 ft. tall. Basal leaves obovate or spatulate, narrowed into a petiole, obtuse, denticulate or entire, hirsute or villous; upper leaves smaller, usually sessile. Heads numerous in a racemose panicle, without leaf-like bracts, 15–20-flowered, on slender glândular peduncles. Involucre of 1 series of principal bracts and several outer ones. Achenes spindle-shaped. Dry soil. July-Oct. Fulton, Erie, Franklin, Gallia, Brown.

Hieracium mariànum Willd. Maryland Hawkweed. Erect, slender herbs, pubsecent at least below, with few to several leaves, 2–3 ft. tall. Basal leaves obovate, obtuse, narrowed at the base, ascending, hirsute on veins below, usually glabrous above; stem leaves smaller. Heads in paniculately branched clusters, 15–40-flowered, peduncles slender. Achenes truncate. May-Aug. Brown County.

Hieracium scàbrum Mx. Rough Hawkweed. Erect, stoutish, leafy-stemmed herbs, hispid below, glandular pubescent above, 1–4 ft. tall. Leaves oblong to obovate or spatulate, narrow at base, obtuse, denticulate or entire, hirsute. Heads on glandular, leafy-bracted peduncles. Involucre with 1 series of principal bracts. Achenes truncate. In dry open woods and pastures. July-Oct. General.

Hieracium pilosèlla L. Mouse-ear Hawkweed. Plants pilose-pubescent throughout, with numerous leafy stolons rooting at the nodes. Leaves oblong to spatulate, entire, obtuse, often white tomentose beneath. Head 1 in. or more broad, usually solitary on a leafless scape. Involucre of 1 or 2 series of linear, pubescent, principal bracts and 1 or 2 series of outer small ones. Achenes truncate. Dooryards and fields. Adventive from Europe. May–Sept. Lake Co.

Hieracium venòsum L. Veined Hawkweed. Slender, widely branched stems, with few or no leaves, 1–3 ft. tall. Leaves tufted, obovate, oblong, or spatulate, purple-veined, glabrous or hirsute. Numerous heads on slender, spreading, glabrous peduncles. Involucral bracts in 1 series. Pappus brown, not copious. Achenes truncate. In dry woods and sandy places. May–Oct. Eastern Ohio to Cuyahoga, Knox, Jackson, and Lawrence Counties.

Hieracium greènii Port. & Britt. Green's Hawkweed. Slender scapose plants, occasionally with 1 or 2 leaves on the stem, 1½–2½ ft. tall. Leaves tufted, obovate to spatulate, narrowed into a petiole, obtuse, bristly pubescent. Branches canescent-tomentose and glandular. Involucre in 1 series of principal bracts, glandular. Flowers yellow. Pappus brown, sparse. Achenes truncate. Dry woods. May–Sept. Highland County.

Hieracium auranttìacum L. Orange Hawkweed. Slender stemmed, stoloniferous, scapose plants, occasionally with 1 or 2 leaves near the base, 6–20 in. tall. Basal leaves tufted, spatulate, hirsute, entire or

denticulate. Several heads in a corymbose cluster, peduncles short. Involucre hirsute or glandular. Flowers orange or red. Pappus a single row of brown bristles. Achenes truncate. Fields, woods, and roadsides. June–Sept. Ashtabula, Geauga, Belmont.

Hieracium pratênse Tausch. Field Hawkweed. Stoloniferous, with blackish hairs on the stem, hirsute or pilose, scapose, sometimes with 1 or 2 leaves near the base, 1–2 ft. tall. Basal leaves tufted, oblanceolate to oblong, light green, entire with a few glandular teeth, hirsute on both sides. Heads less than ⅞ in. broad in a corymbose panicle. Flowers yellow. Involucre pilose or glandular. Achenes truncate. Fields and roadsides. Naturalized or adventive from Europe. June–Aug. No specimens.

11. *Crèpis* L.

Leafy-stemmed or scapose plants with yellow or orange flowers in flat, erect heads. Involucre of 1 series of principal equal bracts. Pappus of very slender white bristles, copious. Achenes cylindric or prismatic, beakless, or nearly so, narrowed at the base.

1. Leaves linear, sometimes sagittate............................*C. tectorum*
1. Leaves lanceolate to oblong or spatulate, clasping, margins not revolute.....2
2. Heads one-third to two-thirds inches broad, outermost bracts of the involucre not spreading....................................*C. capillaris*
2. Heads 1–1½ in. broad, outermost bracts of the involucre spreading, *C. biennis*

Crepis tectòrum L. Narrow-leaf Hawksbeard. Slender, pubescent annuals with branched leafy stems, 1–2 tall. Leaves narrow, entire, dentate or runcinate-pinnatifid, margins revolute; stem leaves sessile, often sagittate. Heads in corymbose cluster. Involucre narrow, pubescent or canescent; bracts lanceolate, acuminate, downy within, exterior ones spreading. Achenes with short beak, 10-ribbed. In waste places. Adventive from Europe. June–Sept. No specimens.

Crepis capillàris (L.) Wallr. Smooth Hawksbeard. Branched, leafy annuals, 8–30 in. tall, glabrous or slightly hirsute below. Basal leaves spatulate, pinnatifid or dentate, tufted, margins not revolute; stem leaves much smaller, lanceolate, sessile or clasping with sagittate base. Heads numerous in a spreading corymb, ⅓–⅔ in. broad, peduncles slender, glabrous or glandular. Involucre oblong, pubescent or glandular, glabrous within, principal bracts lanceolate, outermost not spreading. Fields and waste places. Adventive from Europe. July–Sept. Franklin, Belmont, Lake.

Crepis biênnis L. Rough Hawksbeard. Leafy branched annuals or biennials, pubescent or hirsute at least below, 2–3 ft. tall. Basal leaves oblong to spatulate, narrowed into a petiole, dentate or pinnatifid, margins not revolute; the uppermost lanceolate, clasping. Heads 1–1½ in. broad. Involucre pubescent or canescent, bracts lanceolate, downy within, outermost spreading. Achenes narrowed above. Fields and waste places. Naturalized or adventive from Europe. June–Aug. No specimens.

12. *Nábalus* Cass.

Branched, leafy-stemmed herbs. Heads narrow, cylindrical, few-flowered, usually drooping. Flowers cream, white, or purple. Pappus of simple bristles. Achenes truncate, 4–5 angled or nearly terete.

1. Heads in a long slender thyrsus, numerous; stems simple, wand-like..........2
1. Heads in paniculate or corymbose clusters, more or less divergent..........3
2. Stems and leaves rough-hispid, flowers light yellow................*N. asper*
2. Lower stems and leaves glabrous and glaucous, flowers purplish..*N. racemosus*
3. Flowers 12–35 in a head, involucre hirsute-pubescent..........*N. crepidineus*
3. Flowers 5–16 in a head, involucres glabrous or nearly so....................4
4. Heads 5–7-flowered; involucre less than one-eighth inch wide, with 5 light green bracts..*N. altissimus*
4. Heads 8–16-flowered; involucres one-eighth to one-fourth inch wide, with 6–8 green, purple, or glaucous bracts....................................5
5. Branches of panicle diverging; involucres nearly glabrous, bracts shorter than the pappus..*N. serpentarius*
5. Branches of panicle ascending; involucral bracts glabrous and equalling the pappus in length..6
6. Pappus deep cinnamon brown....................................*N. albus*
6. Pappus straw-color or light brown.............................*N. trifoliatus*

Nabalus ásper (Mx.) T. & G. Rough Rattlesnake-root. Rough pubescent perennials with wand-like simple stems, 2–4 ft. tall. Leaves ovate to oblong or lanceolate, dentate to entire, closely sessile or clasping; basal ones narrowed to winged petioles. Heads numerous, close to stem on a long thyrsus, ¼–⅜ in. broad. Involucre oblong, hirsute, with 8 or 9 principal bracts. Flowers light yellow. Pappus straw-colored. On dry prairies. Aug.–Sept. Erie County.

Nabalus racemòsus (Mx.) DC. Glaucous Rattlesnake-root. Glabrous and glaucous below, with stems and inflorescence similar to the preceding species, perennials. Leaves glabrous and glaucous, basal ones narrowed into a petiole, ovate to oblong to obovate, entire, dentate or pinnatifid; the upper sessile, lanceolate. Heads ⅛–¼ in. broad. Involucres pubsecent. Flowers purplish. In moist places. July-Sept. Fulton, Lucas, Ottawa, Erie, Huron, Wyandot, Champaign, Clark.

Nabalus crepidíneus (Mx.) DC. Corymbed Rattlesnake-root. Stout-stemmed, leafy, branched perennials, 5–9 ft. tall, stems glabrous below, somewhat puberulent above. Basal leaves hastate or deltoid with margined petioles, dentate, lobed, or incised, sometimes 10 in. long; stem leaves smaller, short petioled or sessile, ovate, deltoid, or lanceolate. Heads numerous in a corymbose panicle, drooping, ¼–½ in. broad, 20–35 flowered. Involucres hirsute, green or purplish, with 12–15 principal bracts. Flowers cream colored. Pappus brown. In fields, Aug.–Oct. Cuyahoga, Champaign, Warren.

Nabalus altíssimus (L.) Hook. Tall Rattlesnake-root. Slender, glabrous or slightly hispid, not glaucous perennials, 3–7 ft. tall, stems green or sometimes purplish. Leaves various, hastate to lanceolate, cut or lobed, mostly with long slender petioles. Heads narrow, 5–7 flowered in terminal and axillary panicles, pendulous. Involucres glabrous, light green, with 5 principal bracts. Flowers greenish or yellowish white. Pappus straw-color or cinnamon-brown. Woods and thickets. July–Oct. General.

Nabalus serpentàrius (Pursh.) Hook. Lion's foot. (Rattlesnake-root). Glabrous or slightly pubescent perennials, green, not glaucous, 1–4 ft. tall. Leaves variable in outline, similar to the preceding species. Branches of the panicle divergent. Heads numerous, drooping, 8–12 flowered. Involucre hispid or rarely glabrous, green or purplish, with about 8 principal bracts, shorter than the pappus. Flowers whitish, cream, or yellow. Pappus light brown or straw-color. In dry open woods and thickets. July–Oct. Guernsey County.

Nabalus álbus (L.) Hook. White Rattlesnake-root. Glabrous and glaucous, stems often purplish, 2–5 ft. tall. Leaves variable in outline as in the preceding species. Inflorescence paniculate, heads drooping. Involucre nearly glabrous, glaucous, with about 8 principal bracts. Flowers almost white. Pappus deep cinnamon-brown. In rich woods. Aug.–Oct. General.

Nabalus trifoliolàtus Cass. Tall Rattlesnake-root. Glabrous plants, 1–9 ft. tall. Leaves long-petioled, usually 3-divided, with stalked or sessile divisions; the upper lanceolate, usually cut and lobed or merely crenate. Inflorescence a panicle of ascending branches. Heads few, drooping, with 7–12 pale yellow or whitish flowers. Involucres glabrous of 6–8 principal bracts equalling the light brown or straw-colored pappus. Woods and thickets. Aug.–Oct. No specimens.

13. *Sitilias* Raf.

Leafy-stemmed, branched herbs, very rarely scapose. Our species glabrous or nearly so. Pappus of 5 obovate scales and an inner series of bristles surrounded by a villous white ring at the base. Flowers yellow.

Sitilias caroliniàna (Walt.) Raf. Leafy-stemmed False-dandelion. Glabrous annuals or biennials, 2–5 ft. tall with leafy much-branched stems. Leaves lanceolate-oblong, pinnatifid, dentate, or entire, acute or acuminate; basal leaves narrowed into a margined petiole; stem leaves sessile or partly clasping. Heads few, 1–1½ in. broad. Involucre usually pubescent. Achenes tipped with a filiform beak about 3 times their length. Dry sandy soil. April–July. Not reported from Ohio.

14. *Sónchus* (Tourn.) L.

Leafy-stemmed, banched herbs. Involucres ovoid, campanulate. Flower heads ¼–2 in. broad. Flowers all yellow. Receptacle flat, naked. Pappus of simple white bristles, copious. Achenes flattened.

1. Bracts of the involucre glandular-pubescent...................... *S. arvensis*
1. Bracts of involucre glabrous..2
2. Leaves mucronate, not spiny; auricles pointed; achenes ribbed and transversely wrinkled...*S. oleraceus*
2. Leaves spinulose-dentate or spinulose-denticulate; auricles rounded; achenes ribbed, not wrinkled transversely.......................*S. asper*

Sonchus arvénsis L. Field Sow-thistle. Glabrous perennials with creeping rootstock. Stems leafy below, nearly naked above, 2–4 ft. tall. Lower leaves runcinate-pinnatifid, spinulose-dentate, often 12 in. long;

upper ones smaller, lanceolate, clasping. Heads corymbose-paniculate; 1–2 in. broad, showy, bright yellow. Involucral bracts bristly. Achenes oblong, compressed, ribbed. Fields and waste places. Naturalized from Europe. July–Oct. Lake, Franklin, Belmont.

Sonchus oleràceus L. Common Sow-thistle. Annuals with nearly simple stems, leafy below, 1–10 ft. tall. Leaves pinnatifid or lyrate, narrowed into petioles, terminal segment usually large, margins dentate, mucronate; upper leaves clasping, lanceolate, dentate or pinnatifid, auricles pointed; the uppermost sometimes entire. Heads several to numerous, ¾–1¼ in. broad. Flowers pale yellow. Bracts glabrous. Achenes flat. A common weed in cultivated land and waste places. May–Nov. General in Ohio.

Sonchus àsper (L.) Hill. Spiny Sow-thistle. Hispid annuals similar to the preceding species. Lower and basal leaves spatulate to obovate, pinnatifid or dentate, petioled; upper ones clasping, lanceolate or oblong, auricles rounded. Bracts of the involucre glabrous. Heads 1 in. or less broad. Flowers pale yellow. Achenes flat. In waste places. May–Nov. General.

15. *Lactùca* (Tourn.) L.

Leafy-stemmed herbs with usually numerous heads of white, blue, or yellow flowers. Heads less than ½ in. broad. Involucres cylindrical. Receptacle naked, flat. Pappus of simple bristles. Achenes flat, narrowed above.

1. Flowers yellow....................2
1. Flowers blue or white....................6
2. Heads 6–12-flowered; leaves sagittate, clasping....................3
2. Heads 12–20-flowered; basal leaves petioled....................4
3. Panicles narrow; leaves glabrous, runcinate-pinnatifid, lobes pointed, margins not spinulose....................*L. saligna*
3. Panicles spreading; mid-ribs spinulose, leaves entire or pinnatifid, lobes broad, margins spinulose....................*L. virosa*
4. Leaves lanceolate, acuminate or acute; entire or denticulate, lower rarely pinnatifid, sagittate at the base....................*L. sagittifolia*
4. Leaves obovate, obtuse, crenate....................*L. sativa*
4. Leaves mostly sinuate-pinnatifid, uppermost often lanceolate, entire....................5
5. Leaves hirsute-pubescent on both sides or at least on the mid-rib..*L. hirsuta*
5. Glabrous throughout, somewhat glaucous....................*L. canadensis*
6. Pappus white....................7
6. Pappus brown....................*L. spicata*
7. Leaves oblong to ovate or lanceolate, acutely dentate....................*L. villosa*
7. Leaves deeply pinnatifid or lobed....................8
8. 1–3 ft. tall; leaves linear-lanceolate, lobed or pinnatifid....................*L. pulchella*
8. 3–7 ft. tall; leaves broad, deeply lyrate, divisions broad....................*L. floridana*

Lactuca viròsa L. Prickly Lettuce. Glaucous biennial. Stems glabrous or bristly below, 2–7 ft. tall. Leaves oblong to lanceolate, dentate or pinnatifid, often arranged vertically, margins and mid-ribs spinulose. Heads panicled, 6–12-flowered. Flowers pale yellow. Involucres cylindric, outer series of bracts shorter than the inner. Variety ***integrata*** Gren. and Godr. has oblong denticulate leaves, none of them or only the lowest pinnatifid. A troublesome weed in fields and

waste places. Naturalized from Europe. June–Sept. General and abundant.

Lactuca salígna L. Willow Lettuce. Light green biennial with slender, smooth stems. Similar to the preceding species but with runcinate-pinnatifid leaves, lobes narrow, mid-veins usually not spinulose. Waste and cultivated ground. Naturalized from Europe. July–Aug. Franklin, Green, Montgomery, Highland.

Lactuca sagittifòlia Ell. Arrow-leaf Lettuce. Glabrous biennial, sometimes slightly hirsute below, 2–6 ft. tall, leafy. Leaves oblong to lanceolate, acute, entire or rarely unevenly toothed; stem leaves sessile or clasping; basal ones petioled and occasionally pinnatifid. Heads numerous, small. Involucre cylindric with outer series of bracts shorter than the inner. Flowers yellow or reddish. Pappus white. Achenes oval, with filiform beak. In open dry soil. July–Sept. Fairfield, Cuyahoga.

Lactuca satìva L. Garden Lettuce. Similar to the preceding species but with broader, obtuse leaves; margins entire or crenate. Escaped from cultivation in Franklin County.

Lactuca hirsùta Muhl. Hairy Lettuce. Stems erect, 1–6 ft. tall, sparingly leafy, usually hirsute. Leaves narrow, pinnatifid, hirsute on both sides or only on the under mid-vein; stem leaves sessile or clasping, sometimes entire; basal ones petioled. Heads numerous. Involucre glabrous, outer bracts shorter than the inner. Flowers yellow. Pappus white. Achenes oblong, beaked. Dry open soil. June–Sept. Tuscarawas, Ross, Union.

Lactuca canadénsis L. Tall Lettuce. Glabrous, glaucous annual or biennial, leafy-stemmed, 3–10 ft. tall. Leaves mostly sinuate-pinnatifid; basal ones narrowed into a petiole; the upper sessile or clasping, uppermost often lanceolate and entire. Flowers pale yellow. Outer involucral bracts shorter than the inner. Pappus white. Achenes oval, about as long as the beak. In moist soil. June–Nov. General.

Lactuca spicàta (Lam.) Hitchc. Tall Blue Lettuce. Stout glabrous annuals or biennials, leafy-stemmed, 3–12 ft. tall. Leaves deeply lobed or entire, margins coarsely dentate, mucronate, smooth on both sides but may be pubescent on under mid-rib; stem leaves sessile, lower ones may be narrowed into a petiole. Heads numerous in a rather dense panicle. Flowers blue to white. Pappus brownish. Achenes short-beaked. Low moist ground. July–Oct. Rather general. Variety L. spicata aurea Jennings. A yellow-flowered variety is reported. Holmes, Defiance, Cuyahoga, Franklin, Athens.

Lactuca villòsa Jacq. Hairy-veined Blue Lettuce. Glabrous, leafy-stemmed annuals or biennials, 5–6 ft. tall. Leaves obovate to lanceolate, acuminate, mucronate, glabrous above but veins may be pubescent. Numerous heads on a divergently branched panicle. Peduncles with minute scales. Flowers blue. Involucral bracts mostly obtuse, outer series shorter than the inner. Achenes thick with short thick beak. In borders of thickets. July–Oct. Miami and Montgomery.

Lactuca pulchélla (Pursh) DC. Large-flowered Blue Lettuce. Slender erect perennials, 1–3 ft. tall, leafy-stemmed, glaucous. Stem leaves sessile or clasping, lanceolate, entire; lower ones runcinate-pinnatifid, lobes narrow. Heads numerous on scaly-bracted peduncles. Involucre of 3 or 4 series of principal bracts. Pappus white. Achenes with short slender beak. In moist soil. No specimens.

Lactuca floridàna (L.) Gaertn. Florida Lettuce. Nearly glabrous leafy-stemmed annuals or biennials, 3–7 ft. tall. Leaves large, ovate-cordate, lyrate, rarely entire, petioles margined, segments broad, glabrous above, pubescent on veins below, 4–12 in. long. Flowers blue. Outer series of involucral bracts shorter than the inner. Achenes thick, the beak short, thick. Moist soil. July–Sept. From Erie, Franklin, and Ross Counties west.

16. *Leóntodon* L.

Scapose herbs with hollow naked scapes and large solitary heads. Fruit very slender, roughened, spinulose. Papps of simple bristles. Receptacle naked, honeycombed.

Leontodon taráxacum L. Dandelion. Acaulescent perennials from a deep tap-root. Leaves in a rosette, oblong to spatulate, variously cut and pinnatifid, dentate or nearly entire, according to the age of the plant, the younger being less deeply cut. Scapes hollow bearing a head 1 in. or more broad. Flowers numerous, golden yellow. Outer bracts of the involucre reflexed as the head becomes older. Bracts linear. Achenes greenish, spinulose above, narrowed to a filiform beak which bears an abundant white pappus. Mass of fruit globose when ripe. A common weed in open places all over the world. Several varieties have been noted which bear red, green, or brown seeds. Old plants split longitudinally through the root and rejuvenate naturally. When roots are divided new plants grow which have the characteristics of young plants. Although much pollen develops the eggs are not fertilized. Flowers develop seed parthogenically. This is one of the highest plants in the plant kingdom. Naturalized from Europe. Jan.–Dec. Main blooming period April–May. General and abundant.

NOTES ON THE OCCURENCE OF GLACIAL MATERIAL BEYOND THE BORDER OF THE DRIFT IN MUSKINGUM COUNTY, OHIO.

LE ROY T. PATTON,
Bureau of Economic Geology and Technology, University of Texas.
AND
CLIFFORD HICKS.

From the southeastern part of Perry Township, Muskingum Co., a collection of small erratic boulders has been made by Mr. Hicks, the junior author of this paper. Mr. Hicks was at the time a student of geology in Muskingum College. The collection was largely obtained from the farm upon which Mr. Hicks lived at the time and was mainly discovered in the course of farming operations. The occurence of these erratics were reported to the senior author of this paper who visited the locality with Mr. Hicks, directed the collection of other specimens and examined the final collections.

The locality where these erratics were found is on the east side of Little Salt Creek about three fourths of a mile south of the National Road and in the neighborhood of the Pergory School. The land here slopes very gently to the east of the valley of a small tributary to Little Salt Creek.

All the specimens were found below an elevation of 900 feet. The boulders are all small none of them being over three or four inches in diameter and the majority smaller than this. They consist of quartzite, diorite, dolerite, and granite together with a larger proportion of apparently glacial shaped boulders of native rocks. A number of the foreign boulders are subangular and one granite boulder is striated.

While the collection came from a very small area only it is thought that this is because an intensive study was made of this place and that a thorough study of other areas might yield similar results. A number of other localities where such boulders were said to have been found were reported by neighbors of Mr. Hicks but the writers did not have opportunity to check up these reports.

The occurence of these erratics twelve miles beyond the border of the drift calls for some explanation. Possibly the

most plausible hypothesis is that they were borne there by floating ice. If at the time of the daming up of the old Newark river there had been formed a lake north of the old divide which Leverett* thinks is near the Muskingum-Morgan county line, it seems probable from the configuration of the land that reentrants or embayments of this lake might have extended up to the location where these erratics were found. In that case the occurence of the erratics might be attributed to transportation by floating ice.

It does not seem probable that these erratics were transported to their present location by the aborigines. With regard to some erratics found beyond the border of the drift near McConnelsville Leverett† says that *"it may be necessary to refer the distribution of these erratics to human agency."* With respect to others, however, he expresses the opinion that they have been deposited by natural agencies and that the subject is one requiring further investigation. There is no evidence, so far as could be ascertained, of any former Indian camping ground in the vicinity where the erratics were found such as the presence of arrow heads, etc. The boulders do not show any evidence of use as hammer-stones and are usually not of the shape which it would seem most likely would be chosen for these purposes. Furthermore, the locality is 12 miles beyond the nearest drift border. It seems improbable that more than an occasional stone would be transported this distance unless the locality were the site of a more or less permanent camp in which case there would likely be evidence left of such an encampment.

NOTE. Shortly after the above paper was submitted for publication Professor C. F. Moses read a paper before the Ohio Academy of Science upon somewhat the same subject. The writers were not aware of Professor Moses' work or his intention to present such a paper, but upon learning of its presentation immediately offered to withdraw their paper if its publication would in any way cause any misunderstanding. Professor Moses, however, expressed the desire that the paper be published as the two papers in no way conflicted with each other and represent independent work leading to the same general conclusions.

* Leverett, Frank. Glacial formations and drainage features of the Erie and Ohio Basins. U. S. Geol. Sur. Monograph XLI, p. 156, 1902.

† Leverett, Frank, Op. cit., p. 158.

Date of Printing, February 20, 1925.

THE OHIO JOURNAL OF SCIENCE

VOL. XXV | MAY, 1925 | No. 3

SOME CONSIDERATIONS OF PROTOPLASM.

BRUCE FINK,
Department of Botany, Miami University.

One of the most fundamental problems in biological science is that which concerns protoplasm. Yet there is great diversity of opinion among biologists regarding what constitutes protoplasm and some doubt whether the term protoplasm is really worth retaining. In the present state of knowledge, protoplasm can not be defined in any terms of physical structure which will be accepted, without qualification, by a majority of botanists, and can only be defined somewhat more satisfactorily in terms of colloidal chemistry. Again, though chemical definition is somewhat more certain than physical, this alone is far from satisfactory to those who think of cell contents in terms of microscopic structure.

It is sometimes stated by certain biologists that protoplasm is essentially alike in all organism. This may be true in the rough if we define in purely chemical terms; or if we content ourselves with the statement that protoplasm is the living substance of the cell, knowing not how much of the cell is alive, and, therefore, protoplasm. Turning to those very lowly organized plants, the bacteria, most of us will agree that the whole cell content, inclusive or exclusive of the vacuoles, composes the protoplasm. For higher fungi and for animals the situation is about the same, except that definite nuclei here replace the nuclear granules commonly supposed to exist in bacteria. Turning attention to higher green plants, we find that the cells are much more complex with respect to visible contents. This is especially true of all the cells of lower algae and of those cells of higher bryophytes, pteridophytes, and spermatophytes in which photosynthesis is carried on.

Regarding these chlorophyllous, photosynthesizing cells of green plants, every possible position has been taken respecting the portion of visible cell contents which may constitute the protoplasm.

Knowing well that the problem was not a very fundamental one, the writer, like other teachers and investigators, has had to puzzle about what visible and therefore obstrusive portions of the protoplast or whole cell content should be regarded as protoplasm. Finally, in November, 1923 he addressed a questionnaire to about sixty teachers in colleges and universities, merely asking which of these elements each one would regard parts of the protoplasm. More than forty replies resulted from the letters; and the views expressed were readily arranged in four general catagories for presentation at the meeting of the Botanical Society of America at Cincinnati, in December, 1923. Following this, those who had not replied and a few others were circularized, asking which of the four catagories which resulted from the first letters each one would favor. The result of the two efforts was more than sixty replies. The circular letters stated that the writer would feel free to quote from the replies; and quotations from some of the most valuable discussions will form an important portion of this paper. The statistical results might have been more valuable if a larger number of botanists had been consulted. Yet the selection of persons whom to address was carefully made; and the writer believes that what follows will be found valuable, especially to those who have had little time for the formulation of a basis for thinking and teaching regarding protoplasm.

Seven of the botanists who replied adhered to one position which grew out of the questionnaire, namely that protoplasm consists of cytoplasm and nucleoplasm, the latter more commonly in the form of a definite nucleus. The adherents to this belief are H. C. Cowles, R. P. Hibbard, E. C. Jeffrey, O. E. Jennings, C. B. Lipman, G. B. Rigg, and A. R. Sweetser. After a general discussion, Hibbard says "In many cases I would agree with class two, but there are some masses of nucleated protoplasm that do not contain plastids. So to cover all cases I would take my stand with class one." In explanation it should be stated that class two as presented at Cincinnati is the next following. Jeffrey says in part "I suppose, strictly speaking, the term protoplasm should be limited to the nitro-

genous, undifferentiated contents of cells. If one goes beyond that, I do not see how it is possible to avoid everything, including the wall." The present writer began many years ago with the belief held by these seven men, but turned recently to the view that the whole cell content should be regarded as protoplasm. However, the wall is like certain cell inclusions with respect to origin, and he sees plainly the force of Jeffrey's logic. The following from Jennings is peculiar: "Possibly plastids have as their original basis certain differentiated portions of the protoplasm, just as I would consider the nucleus a highly differentiated portion of the cytoplasm." Of course the relation of plastids and nuclei to protoplasm and cytoplasm depends in part on definition of these last two components of protoplasts, and the writer is content for the present to quote Jennings without further comment.

After stating his view, Cowles says "I have talked with Chamberlain, who gives our Cytology courses, and he also treats the subject as I have." It appears, however, that Chamberlain believes quite differently. He says "For convenience of reference, I use the terms cytoplasm and nucleus; but I do not use the term protoplasm to cover the two taken together. Whenever we use the term protoplasm at all, we use it loosely as a synonym for cytoplasm." Shull's statement, quoted in full later in this paper, differs from both Cowles and Chamberlain. There are advantages in likeness of presentation within a department; but of course independence in thinking is preferable. Coulter referred the writer to Shull as spokesman for the department; but it is stimulating to find that the department cannot be spoken for by one man.

According to the best analysis that the writer can make, thirty-eight botanists addressed took essentially a second position which grew out of the questionnaire, namely that protoplasm consists of cytoplasm, nucleoplasm and plastids. These botanists are G. M. Armstrong, H. W. Barre, H. H. Bartlett, A. R. Bechtel, D. H. Campbell, A. H. Chivers, H. S. Conard, M. T. Cook, O. F. Curtis, B. M. Davis, A. W. Evans, J. H. Faull, M. C. Ferguson, W. F. Ganong, W. A. Gardner, F. O. Grover, J. W. Harshberger, D. S. Johnson, F. D. Kern, J. E. Kirkwood, B. E. Livingston, J. N. Martin, H. F. A. Meier, F. T. McFarland, A. Nelson, S. P. Nichols, L. H. Pammel, R. J. Pool, J. H. Schaffner, W. A. Setchell, L. W. Sharp, C. A.

Shull, A. G. Stokey, E. N. Transeau, W. Trelease, A. E. Waller, K. M. Wiegand, and R. B. Wylie. Davis qualified by calling attention to the fact that plastids are not present in parasitic and saprophytic plants. Faull stated that "pyrenoids are looked upon as specialized areas within the plastids and constitute a part of the plastid substance." This statement is related to the addition of pyrenoids by one or two other botanists. Johnson added that blepharoplasts are sometimes to be included. Martin would add pyrenoids and chondriosomes. Sharp referred me to his text on Cytology, and it would seem from statements, pages 133 to 135, that he belongs with this group. Wylie would add to cytoplasm, nucleoplasm, and plastids the plasma membrane. Bartlett wrote at considerable length, and want of space compels doing injustice to his valuable statement by passing it with record of the fact that he regards water and chlorophyll parts of protoplasm.

Campbell's statement is much shorter, and it represents the general belief of these 38 botanists fairly well. His statement runs thus: "In discussing protoplasm before my classes, I have considered the whole living contents of the cell, cytoplasm, nucleus, and plastids as constituting the protoplasm. I should not include vacuoles, starch grains, protein granules, or cell wall under this head; and I have tried to make clear to students that we can not look upon protoplasm as a definite chemical substance, but that it is a mixture of a very great number of complex substances, and is in a state of constant change, due to the activities within. Hence no chemical analysis can represent the true composition of living protoplasm as it must also include various inclusions of the protoplast which are not constituents of the living protoplasm."

Livingston's 800-word statement deserves quoting as a whole, but we can take space only for the following, which contains an interesting thrust and several very illuminating comparisons. He says in part "I don't care what protoplasm is so long as we know how it is built and how it operates. The problem is somewhat like asking for a definition of soil or air. If I take the water out of the soil or air, I still have soil or air. If I take the nitrogen out of air, it is still air, I suppose, but perhaps it isn't if I take the oxygen out. Take the dissolved salts out of soil, or take the dissolved gases out of soil, and it is still soil. But take the solid grains out, and we don't consider

it soil any more, even though the undissolved gases are present, as in sea foam. It seems foolish to try to define air, or soil, or protoplasm, or mince-meat, or plum-pudding, or chocolate fudge, or house-paint. When we attempt to define them we discover that there are many kinds of each, and that all of the constituents of any one mixture may be left out and replaced by different materials, without requiring the use of another general term. If a whole apple were found in the middle of the plum-pudding, we'd not call it a part of the pudding any more than if it were the baby's rubber doll that had been included by mistake. But if we took all of the dead grapes out of the plum-pudding, it wouldn't be a plum-pudding any more! Apparently the distinction is based largely on size. Small pieces of apple are part of mince-meat, but larger pieces (fix your own limits of size) would be considered foreign bodies surrounded by mince-meat." It is from other portions of his discussion that it was concluded that Livingston believes in a general way that protoplasm consists of cytoplasm, nucleoplasm, and plastids; and some violence has been done in taking the above quotation out of its setting because of its intrinsic value.

Shull has expressed himself as follows: "For some time I have used the criterion of actively living substance for living protoplasm; and for dead protoplasm, such material as had been once actively living. I have never considered the vacuoles, starch grains or protein granules, or oil droplets as real parts of the protoplasm. They are parts of the cell when one is classifying the structures found in the cell unit of structure; but I would consider the starch grains and other food inclusions as mere storage products, stored temporarily and conveniently in the region of living substance for more or less immediate use. But I do not see how we could consider them parts of the living substance until they had been assimilated and synthesized into metastable protoplasm molecules of some kind. On the other hand there is reason for considering chloroplasts and leucoplasts as protoplasmic bodies, likewise mitochondria. Certainly a part of their substance is actively living, whether the chlorophyll is or not. From this point of view the wall would hardly be called living matter. It is no more alive than the starch grain, and like the starch grain may be considered the condensed product of enzymic action on the soluble carbohy-

drates. It seems to me highly probable that the pyrenoids, like chloroplasts are real protoplasmic bodies. It now becomes necessary to state what is meant by Being alive as used above. By that I mean possessing the power to carry on the peculiar synthetic and destructive chemical processes which involve utilization and release of chemical energy. If one includes all the structures that you mention, and adds the cell walls, there is just as much reason for adding crystals of calcium oxalate and other crystalline inclusions, according to which the whole body becomes protoplasm and the term protoplasm absolutely devoid of meaning." This statement was referred to in connection with the statements of Cowles and Chamberlain. In a number of important respects, it differs from all other statements, and, therefore, it is of special interest.

After stating her position, Miss Stokey says "My inclusions and exclusions are based in part on their origin and in part on their persistence or stability. I include in protoplasm the parts of the cell which arise from the division of similar parts and not those which arise *de novo.* I do not include those parts which maintain their identity after the death of the cell or which do not have the unstable structure which is characteristic of cytoplasm and the nucleus,—structures which die." Nothing similar to this very suggestive statement has occurred elsewhere in the correspondence.

Five botanists who replied took a third position which was an outgrowth of the questionnaire, namely that the unit of protoplasm is the protoplast or whole cell content. These botanists are C. E. Allen, C. O. Appleman, T. C. Frye, J. B. Overton, and R. Stratton. Allen says "Both in print and in speech there is a good deal of confusion among biologists as to just what we mean by protoplasm and cytoplasm. We have thrashed over the question here at various times, and have always come back to the definition which—I think, was originally due to Strasburger—namely, that protoplasm includes everything within the wall, and that cytoplasm includes all the protoplasm except the nucleus. In case there is no wall or equivalent non-living structure, the whole substance of the cell is protoplasm. These definitions are at least workable. When we come to the question of just what parts of the protoplasm are living and what are non-living, we find ourselves involved in endless discussion. To attempt, as some

do, to define protoplasm as living matter makes the definition depend in turn upon just what is meant by living matter—a conception which no one at present can define." This strong statement may well stand for the view that the whole protoplast constitutes the protoplasm. In connection with it, the logic of Jeffrey and the statement of Shull about what it means to be alive should be recalled.

Appleman is in general accord with Allen, but the following must be quoted: "The protoplasm of the cell may be conceived to consist of a polyphase colloidal system with systems within systems. The nucleus would be a system within a system. Smaller systems may exist within the nucleus. Each system is bounded by a surface membrane which is an integral part of the system and merely represents local concentration of certain constituents of the system. In the development of this conception I include in protoplasm not only the biocolloids but all other substances dispersed in the dispersion medium, as salts, sugar, starch grains, etc." It seems possible from Appleman's statement regarding membranes that he may regard the cell-wall part of the protoplasm.

C. C. Curtis and R. B. Harvey follow the fourth and last position arising from the questionnaire, namely that the whole cell, including the wall, constitutes the unit of protoplasm. Also it is not certain that Appleman should not be placed here rather than with the last group above. O. F. Curtis was placed in the second group,—but he has strong leanings toward the present one. First he says "Ordinarily I would consider statement number 2, 'Plant protoplasm consists of cytoplasm and nucleus, plus plastids,' perhaps the easiest working basis for distinguishing protoplasm from other portions of the cell." Then, after a statement somewhat similar to Allen's, he says "For this reason I often point out that your statement number 4, 'Plant protoplasm consists of the whole cell content plus the cell wall,' is in many respects less disturbing, for there is then no danger of leaving out any part that may be of great importance in the wcrking of the cell." The two quotations from the writer are from the catagories used at Cincinnati. R. A. Harper referred the writer to his discussion of "The structure of protoplasm" in his presidential address for the Botanical Society of America, at the Pittsburgh meeting, December, 1917. The writer understands that this

paper favors the view of protoplasm considered in this paragraph; but there was no thought of attempting to define protoplasm, except for the purpose of the discussion at hand, and one might well object to being held for a position taken for a special purpose several years ago.

Finally, we have reached a group of botanists whose statements cannot be classified according to the criteria used in this paper. R. C. Benedict, E. A. Bessey, B. M. Duggar, F. E. Lloyd, W. J. V. Osterhout, G. J. Peirce, and H. E. Pulling constitute this group. Benedict regards the idea that cytoplasm and nucleoplasm constitute protoplasm "standard and teachable in elementary courses." He thinks the definition which would add plastids "not worth consideration as distinct from others," presumably because he regards plastids as part of the cytoplasm. He believes also that the protoplast, or this plus the wall, may be regarded the unit of protoplasm. He says these dispositions are "both defensible but require more than elementary courses to develop and be understood." Bessey says in part that he agrees with Sharp on some points and differs on others. Part of his statement runs thus: "I think we must look upon the protoplasm of the cell, not as a series of small biophores floating in a non-living medium, but as a polyphase colloidal system whose chemical and physical inter-actions are the phenomena which we interpret as life phenomena. It would be idle, then, to say that there is only one particular chemical substance in the cell that is alive and that the rest is not alive. It is the sum total of the protein and related substances that contribute to the life phenomena." The statement is no less valuable, simply because the present writer does not attempt to place it in his scheme. Apropos of placing Sharp and not placing Bessey, who agrees in many respects, it may be added that Schaffner, Sharp, Livingston, and one or two others might perhaps have been placed in this galaxy of botanists who seem to be unclassifiable for our present purpose.

Duggar, it appears to the writer, has made a contribution which no doubt reflects the feelings of some others with respect to being classified, and which may be otherwise more valuable because it does not fit into our scheme. He says "It is extremely difficult and often unfortunate, it seems to me, to

commit one's self to categorical distinctions. To the enumeration of four categories designated in your letter the criticism might be made that no one of them would properly define protoplasm at all times; for example, at an early stage of growth a plastid might be protoplasmic, while later, though recognized morphologically as a plastid, it might be made up largely if not entirely of fat or gum-like materials. Since the protoplasm frequently penetrates the cell wall, the cell wall must often be an intimate part of the whole unit, but it may be that this is not always so. In the same way one can work out a close relationship between almost any product of the cell and the cytoplasm or nucleoplasm, and it would be difficult to say just when sufficient 'control' of a product ceased, or when it became less subject to the coordinating properties of the protoplasmic matrix. In short I could not accept any of your four categories in toto."

Peirce replied in terms of colloidal chemistry. His statement was prepared carefully for a forthcoming text book, and we quote it in full as follows: "Protoplasm is a colloidal mass in which water and a great variety of substances exist together, the water being the solvent of many of these substances, the medium of colloidal suspension, and of emulsion of others, thus being external to some and enclosed in others, and therefore held with a firmness which may be overcome only with the application of great force. The various colloidal systems forming the colloidal mass called protoplasm may have only water in common; for they may consist of water and gelatinous substances, sols or gels, the water being external to and suspending the sol or gel and escaping with ease, or enclosed within the gel and removable only on the application of many atmospheres of pressure; of water and proteins, complex compounds with large molecules, which are condensation products of amino-acids, behaving like acids toward strong bases and like bases toward strong acids, since they contain groups, carboxyl and NH^2, giving them these respective properties; and of other substances. Thus we have, in its static condition, an enormously complex mechanical, physical-chemical, physiological system; but since it does not exist in a perfectly static condition, the complexity of the system is added to directly in proportion to the activity of the protoplasm, and

its activity is entirely dependent upon the relative proportions of the actions and reactions of the members, inclusions, and products of its component colloidal systems."

In the letter which accompanied this statement, Peirce says "I am somewhat amused to think of the contrast between this statement and some which you will no doubt receive from others of the sixty to whom you have sent this letter. I can imagine, for example, my colleague, Dr. Campbell, scarcely using a single one of the words which I have employed, and yet his idea of protoplasm is as clear and definite as mine, perhaps more so." The reader is here referred to Campbell's statement in a previous paragraph of this paper. It seems more understandable for the beginner, though no doubt more open to criticism than Peirce's statement.

Pulling has likewise failed to see any great value in the classification used in this paper, but has made a keen analysis of the situation regarding protoplasm. His statement runs thus: "I do not see how it is possible for anyone to subscribe to any of the four statements, because the terms are not the same. Protoplasm is, I think, generally intended as the name of a hypothetical living substance. By hypothetical I merely mean that no substance has ever been indentified as living, but the conviction remains that it will be some day found. When found it must be indentified by how it behaves. Nucleus cytoplasm, plastid, cell wall are all topographical terms. They refer to parts of the cell. How then can one say that protoplasm consists of these things? Of course it may be so. If what the microscopist sees when he looks at cytoplasm is living matter, then it is protoplasm. But all he knows is that what he sees is a portion of the cell in which (by definition of the term protoplasm) there is protoplasm while this portion of the cell exhibits those characteristics that we consider are indicative of life. I do not think this is splitting hairs. A crystal within the cytoplasm is termed an inclusion, so is a fat droplet. What evidence is there that all the visible colloidal material is not also an inclusion? The protoplasm may be an infinitely diluted constituent. I think that we need not hesitate to say that there is protoplasm in nuclei, cytoplasm, plastids, and in all cell walls during part of their life, or existence as part of a living cell, using the term protoplasm as defined above. I don't see that the problem of protoplasm or of life,

or of the functions or characteristics of cell parts is the clearer for such a statement, but I make it in the hope that it will be of service to you." Pulling's statement seems unanswerable, and if, by any chance, protoplasm is the attenuated substance which he thinks it may be, the beliefs of all who have contributed to this paper are wrong. Whatever may be the nature of protoplasm, his arguments, like those of Duggar, strike a hard blow at the method of classification used in this paper and many other current treatments of protoplasm.

Osterhaut states that in a broad sense he used the term protoplasm to include the whole cell content and in a narrower sense he excludes vacuoles, crystals, oil drops, starch grains, etc. He seems at one time to belong to our second group and at another to our third.

Because of lack of space, there are some answers not quoted, which contain matter that would add considerably to the merits of this paper. Among these are the replies of Bartlett, Cook, Harvey, Kern, Lloyd, Pammel, Pool, and Shaffner. Some of the points made in these replies will appear in the summaries below.

Summarizing first on the four points which are the main outgrowth of the questionnaire, seven botanists replied to the effect that protoplasm consists essentially of cytoplasm and nucleoplasm. Thirty-eight would add to this plastids, and some of them one or two other portions of the protoplast. Five would make protoplasm synonymous with the protoplast, or whole cell content. Two or three would add to this the cell wall. Seven sent in replies which cannot be classified according to our scheme. Two heads of departments, J. M. Coulter and E. M. Freeman, referred the writer to other men in their departments.

On other matters partly suggested in the questionnaire, thirteen have referred to protoplasm as the living matter of the cell, and two have stated that it is not possible to distinguish between living and non-living. Ten have emphasized the fact that protoplasm is a polyphase colloidal substance. Six regard vacuoles, with their cell sap, part of the protoplasm, and thirteen have stated that vacuoles should be excluded. Five regard pyrenoids a part of the protoplasm, and three would exclude them. One would make chlorophyll a part of the protoplasm, and five would exclude it. Blepharoplasts,

chondriosomes, and centrosomes are each mentioned by one or two as parts of the protoplasm. Three mention water as a portion of protoplasm, and an equal number would exclude it. Two would include that portion of water which is in intimate relation with other portions of protoplasm and exclude the rest. Protoplasm and cytoplasm are regarded as synonyms by two botanists. These data give some idea of the unsettled condition of opinion on some points not otherwise summarized herein.

An occasional reply mentions food material, mucilage, gums, inulin, sugars, fats, oils, resins, tannin, aleurone, enzymes, acids, crystals, cystoliths, and other miscellaneous substances as not belonging to protoplasm. Of course those who regard the protoplast or the whole cell the protoplasmic unit would include whatever of these might be present in any cell as part of the protoplasm of that cell. However, these substances were uniformly mentioned by persons who take a more limited view of the composition of protoplasm.

Some interesting comments were made respecting the cell wall. Three persons stated that the wall contains protoplasm, and two of these regard the wall partly alive. Martin says "In the more advanced classes, I teach that in some cases at least a portion of the wall is modified cytoplasm still living. There are a number of cases where this is certainly true. I have recently been working on the papillae of the stigma of the Easter Lily, finding that the inner one-half or more of the wall is modified cytoplasm still maintaining life sufficient to modify itself into a mucilaginous substance. Strands of wall and cytoplasm grade into each other."

We have classified as best we could the opinions of a considerable number of botanists regarding the nature of protoplasm, viewed from the standpoint of visible cell contents. We have also considered some replies which do not fit into the system of classification used herein. For the writer, the results would seem worth while, even if he got no more from them than the reactions of many botanists on a problem so important, so difficult, and so little understood. Yet it seems scarcely possible that any botanist, except possibly those who have spent most time on the problem, could study carefully what has been presented without having his ideas regarding

protoplasm modified in some manner and his understanding of this very difficult and unsettled problem enlarged.

While no new idea has been advanced in this paper concerning protoplasm, some very interesting and illuminating statements have been introduced; and we have run the whole possible gamut from the notion that protoplasm is synonymous with cytoplasm to the other extreme which makes the unit of protoplasm coextensive with the cell. Pulling has injected the idea which one finds occasionally that we may not see protoplasm with our microscopes, this substance being perhaps so finely granular as to be ultramicroscopic. In view of diversity of opinion, it is questionable whether we had better say much about protoplasm, and even whether it might not be better to abandon the term and speak and write wholly in terms of cell structure. Chamberlain makes little use of the term, and Harper asked at Cincinnati, perhaps half in jest, whether we might not get on better without using the term protoplasm.

The position that protoplasm consists of cytoplasm and nucleoplasm is very indefinite since cytoplasm may mean anything from the more finely granular material of the cell outside the nucleus to the whole cell content outside the nucleus. It is probable that all those who took this view had the first position in mind; but Miss Stokey has given reasons why the position which would add plastids and some other inclusions which arise from division is much more tenable. This is the position taken by nearly two-thirds of the botanists who replied; and the writer is willing to modify his previous position and accept this tentatively, not because it is the majority opinion, but for reasons stated in this paragraph and elsewhere in this paper. Though accepting it for the time, the writer thinks that a view of protoplasm which stops short of the whole protoplast is so difficult to present to elementary students that he will probably be content to touch protoplasm lightly as the living substance of the cell and give the remainder of the discussions in terms of cell structure. In advanced classes he expects to treat protoplasm as a polyphase colloidal system, and state the various ideas regarding what portions of the cell may or may not be protoplasm. Of course all belongs to the complex colloidal system whether protoplasm or not.

Next in order, we may consider the not commonly accepted position which the writer held when he began this investigation, namely that the unit of protoplasm and the protoplast may be regarded as synonymous. This position rests, at least in part, on the facts that every part of the cell probably contains protoplasm at some time and that we have not yet made a good beginning of ascertaining what is and what is not alive, or what is and what is not protoplasm. The writer very reluctantly recedes from this position which is the most workable one that can be taken and has at the same time strong arguments in its favor. As brought out previously in this paper, the inclusion of the wall in the idea of the unit of protoplasm is the logical position for those who include the whole protoplast.

Two men, Buller and Mottier, were quite insistent at Cincinnati that protoplasm should be passed over as "the physical basis of life" or the living substance of the cell. Biologists can agree on this much. Dismissing the supposition that protoplasm may possibly be an attenuated ultramiscropic substance of which we know nothing, doubtless we will also agree that it is a complex colloidal substance, the chemistry of which is not yet thoroughly known. Beyond this, there is no agreement regarding protoplasm, except that cytoplasm or some portion of cytoplasm is protoplasm. A careful analysis of opinions of botanists quoted in this paper brings one to this peculiar conclusion. Consequently, no more inclusive position with respect to the physical content of protoplasm can be assumed certainly; and we should take our positions with great respect for the opinions of others.

How long we may have to continue in this uncertain state of mind respecting protoplasm is wholly problematical. Though most of our ideas of protoplasm are at present quite hypothetical, biologists and chemists have accomplished a good deal in this very difficult field of research. With further study, it seems probable that the fragments of knowledge may be rewoven from time to time until the woof of knowledge regarding protoplasm may be fairly complete.

In the present state of knowledge of protoplasm, the matter of prime importance is that we should not feel so certain of any position taken as to attempt to treat as established that which is quite uncertain. The few well established facts may

be stated with confidence. But the many points that are purely hypothetical should be handled in research and in teaching without attempting to hold any one position to the exclusion of the possibility of another one being preferable. If, then, rather than attempting the impossible in way of reaching some positive position, this paper may contribute to open mindedness respecting protoplasm, and suggest treatment commensurate with present knowledge, it will have accomplished the best possible service.

Finally, the writer wishes to express his very great appreciation of the aid given so generously by busy workers.

SOME OBSERVATIONS OF A PLANT COLLECTOR ON THE ISLAND OF HAINAN.*

F. A. McCLURE,
Assistant Professor of Botany, Canton Christian College.
Agricultural Explorer to China, U. S. D. A.

The island Hainan lies just off the coast of Kwangtung, the southermost province of China, in about the latitude of Porto Rico. It is about four times as large as that island, being roughly 150 miles long by 90 miles wide.

It has been a center of interest to the Chinese since early times, having furnished an important source of incense wood and drugs, two products traditionally very essential to the life of the Chinese people. Situated as it is just within the tropics and in close proximity to China, Indo-China, Formosa and the Philippines, and having high, densely wooded mountain ranges, Hainan has long been an inviting field to botanists. From time to time Western naturalists have visited the island. Few, however, have done more than briefly to skim the coastal plain for plant novelties.

Misfortune has so often been the lot of those who have attempted to penetrate to the interior of the island that a tradition of extreme inaccessibility has grown up around it. Started first by the Chinese soldiers whose comrades died by the hundreds of fevers and unfamiliar diseases when expeditions were sent to suppress the wild people in the interior, the stories of the unhealthfulness of the climate were confirmed by the westerners who have traveled there.

Of particular interest and fascination is the Five Finger Range of mountains which, being the highest and occupying a central location, offers a fruitful field to both the geographer and the botanist. Spurred by the unsuccessful and, in two instances, fatal attempts to reach the summit of this range, the late Mr. G. W. Pearson, then British Consul at Hoihow, set out on a journey in 1910 for the purpose of accomplishing that feat. He was well equipped in every way and was ac-

* From an illustrated lecture delivered before the Botany Section of the Ohio Academy of Science at Columbus, Ohio, April 19, 1924.

companied by a British lieutenant and Mr. Newton of the American Presbyterian Mission. They spent a month in the interior but returned baffled in their attempt, due to constant rain, fever and the reluctance of the natives to lend a hand. Mr. Pearson in his diary wrote very eloquently of the difficulties involved, and prophesied most interesting botanical and other discoveries for anyone who should overcome the obstacles that had so far proved insurmountable. It gave me therefore something of a thrill when the Canton Christian College sent me to Hainan, first in September, 1921, for the purpose of exploring its plant resources and of reaching, if possible, the summit of the Five Finger Range.

As to the topography of the island, the northern third is level or gently rolling, with an occasional extinct volcanic crater. The soil of the northeastern portion is obviously of volcanic origin. The southern two-thirds of the island is very mountainous, but I saw no craters there.

The inhabitants of the island comprise three distinct groups: the Chinese, the Miao and the Loi. The Chinese occupy all the farming lands which are most desirable from the point of view of fertility and accessibility. The Miao, an aboriginal people in the island, are still in a very primitive state, living by migratory agriculture and by hunting with bows and arrows. They live in the mountains and resist Chinese authority. The Loi are related to the Shans and Laos of Indo-China, and are thought to have come to Hainan in prehistoric times in search of the incense woods for which the island is famous. They are for the most part wild, resisting government by the Chinese. These primitive peoples of the interior have some intercourse with the Chinese as they come out on certain days to the border market towns to exchange their rattan and crop surplus for salt, colored yarn and a few other Chinese articles of trade. During the four months I spent on the Island I was mostly among the Loi aborigines near the Five Finger mountains.

Proceeding in a southwesterly direction from Hoihow, the chief seaport of the island, one passes thru fertile farming country, the soil of which is largely of volcanic origin. This region is occupied by Chinese and civilized Loi. The chief crops noted are: rice, both upland and irrigated, sugar cane, beans, indigo, peanuts, and here and there a field of scraggly

cotton. The Litchi thrives wonderfully in the stony country around the extinct volcanic craters. Coconut palms are very common. I saw one fine orchard of tea oil trees (*Thea Oleosa* Lour). The betel nut palm (*Areca catechu* L) is grown extensively in the eastern portion of the island along the Kachek River. At about 75 miles southwest of Hoihow one reaches Nam Fung, the last Chinese outpost on the northern edge of the interior country inhabited by the wild Loi.

The agriculture of the Loi is exceedingly primitive, and being semimigratory in part, results in the complete desruction of the virgin forests everywhere except on the upper slopes of the mountains. Where wet rice culture is practiced the terraces are not plowed but treaded into the proper consistency with water buffalo. A most striking practice is that the grain is stored in granaries in the head and threshed meal by meal, just as it is needed!

As regards the plants used by the Loi for different purposes, they are mostly the same as those used by the Chinese generally. Rice is their main crop, and to it they give their most serious attention. They cultivate many varieties, both irrigated and dry land, starchy and glutinous, red grained, white grained, and red bearded. They grow also some flint corn and sweet potatoes. They now and then have a little patch of raggee (*Eleusine coracana* Gaert), cassava (*Manihot utilissima* Pohl), Job's tears (*Coix lachryma-jobi* L.) or *Sesamum orientale*. Their vegetable gardens are given over mostly to tobacco and isolated specimens of plants such as *Rumex sp.*, and *Celosia sp.* and others which are supposed by them to possess medicinal value. *Basella rubra L* is found rather commonly, and serves as a vegetable. They usually have a few red peppers of which I saw now and then a white variety. About the only vegetable they cultivate with any care or regularity is the pumpkin. Nearly every hut has its pumpkin arbor whereon the vines grow profusely. The flowers and young leaves are cooked and eaten, as well as the fruit both green and mature. They also cook and eat the young fruits of *Carica papaya* L. They sometimes use as vegetables the green leaves of *Iresine herbstii* Hook and a variety of other wild herbs, including other Amarantaceae, the heart of the wild banana plant (*Musa para disiacea var seminifersa* (Lour) Baker) and a pungent, spiny little herb,

Eryngium foetidum I tried them all—and found them better than none.

Fruits they do not cultivate seriously. But nearly every village has a tree or two of jackfruit (*Artocarpus integrifolia* L), pomelo (*Citrus decumana* Murr), and occasionally a litchi, mango or tamarind tree. The Loi seem to relish fruits, and knows every wild fruit that is edible. From the wild they get garcinias, rose apples, litchi, a small citrus fruit, large figs and many others.

In their simple lamps they use the oil expressed from the seeds of castor bean (*Ricinus communis* L), the physic nut (*Jatropha curcas* L) the wood oil tree (*Aleurites moluccana* (L) Wild), the domba oil tree (*Calophyllum inophyllum* L) and the tea oil tree (*Thea Oleosa* Lour). These plants are all semi-cultivated.

The fruiting heads of Thysanolena maxima are stripped of their seeds and bound together with split rattan into brooms. *Imperata cylindrica* Beaur is the grass always used to thatch their roofs. The bamboos (*Bambusa spp.*, *Dendrocalamus spp.*, and *Schizostachyum spp.*) both cultivated and wild, are indispensible to these people.

As to their relatives on the mainland, they use the sap of the sack tree (*Antiaris toxicaria* Lesch.) in preparing an arrow poison. They make a blue dye from the leaves of *Strobilanthes flaccidifolius* Nees, while the Chinese use a species of Indigoferum or Polygonum. For thread and cloth they use the fibres from *Gossypium hirsutum* L. *var arborescens* a tall perennial shrub which grows half cultivated around most of the villages. The coarse fibres of two species of Helicteres, of *Abroma augusta* L. and others are also used. *Boehmeria nivea* Gaudich is sometimes cultivated for its fibres. The ribbon-like leaves of *Pandanus spp.* are woven into hats and coarse matting. *Cyperus tegetiformis* Benth is used also in making matting. The leaves of several species of Licuala are dried and used to make raincoats. One of the most useful wild plants found in Hainan is the rattan. Several species of Calamus are gathered by the Loi for their own use as well as for the market. The raised floors of their houses are made from it. It provides tough thongs with which to bind the house frames together, to make bow strings and to mend many things.

One of the most prominent and beautiful trees occurring in the open, deforested country is the Formosan sweet gum (*Liquidambar formosana* Hance). Upon these trees there lives a species of wild silk worm from whose silk glands the silk gut of commerce is made by a very interesting process.

The known flora of Hainan had been, up to the time of my exploration there, only 370 species. My collections increased that number to 1375 species, an addition of about a thousand species. The complete collection contains 2231 numbers, representing 1118 species, which are distributed in about 150 families and 660 genera. Of these nearly 100 species are new to science. One family, Ochnaceae, of 38 known genera and many species was reported from China for the first time. Dr. E. D. Merrill, until lately Director of the Philippine Bureau of Science, determined the plants with the exception of the grasses, which were determined by Dr. A. S. Hitchcock, and the orchids, which were determined by Mr. Oakes Ames.

Among the plants collected were many of economic promise, such as lumber plants, drug plants, textile plants, food plants and many promising ornamentals. Many of the new species are of special interest, of which Taractogenos hainanensis Merr, a new member of the famous Chaulmoogra oil-yielding group (Flacourtiaceae); *Ficus palmatiloba* Merr., closely related to our cultivated fig; and *Schizostachyum hainanense* Merr., a climbing bamboo, are worthy of mention. There were also: a new Pandanus, two new Licualas, several new members of the Ginger family, a new Quercus, a new Castanopsis, a new Piper, two new Kadsuras (Magnoliaceae), two new Polyalthias and three new Fissistigmas (Annonaceae), seven new members of the Lauraceae, of which three are Cryptocaryas, and many others.

I was able to make only a light impression on the flora of the island during the 120 days I spent there. The other high and extensive mountain ranges which have never been touched will doubtless yield another thousand or possibly two thousand species.

I succeeded in reaching the top of the Five Finger Range and found the altitude of its highest peak to be 7300 feet.

DESCRIPTIONS OF FOURTEEN UNDESCRIBED SPECIES OF PARTHENICUS (HEMIPTERA, MIRIDÆ).*

HARRY H. KNIGHT
Iowa State College, Ames, Iowa

The following descriptions cover material collected by the writer during 1917, chiefly in Arizona, while a member of the Cornell University biological expedition, combined with material collected in the same state during 1924, by Mr. Andrew A. Nichol. Paratypes, where available, will be deposited in the Cornell University collection and in the Arizona Agricultural Experiment Station collection.

Parthenicus nicholi new species.

Allied to *vaccini* V. D., but distinguished by the opaque white color, paler femora with minute fuscous dots only, and by the orange red mark on membrane bordering inner apical angles of corium.

♂. Length, 2.7 mm., width 1.08 mm. Head: width .57 mm., vertex .28 mm. Rostrum, length 1 mm., reaching upon base of genital segment. Antennæ: segment I, length .20 mm., white, a transverse black mark on dorsal surface at slightly beyond middle, formed by blackish occurring at base of three setæ; II, .80 mm., pale, with seven to nine black dots strung out on dorsal surface; III, .54 mm., pale; IV, (shriveled) dusky. Pronotum: length .40 mm., width at base .91 mm. Color white, opaque, head yellowish, mesoscutum and base of scutellum dusky; nearly all pubescent hairs except those on head with a blackish dot formed at base, the spots larger and more prominent anteriorly and laterally on pronotal disk; membrane pale whitish, lateral margins with two fuscous spots much as in *vaccini*, but in addition with several pale fuscous spots on discal area; anal area fuscous, veins white, cubitus red at base which joins with small orange red area bordering inner apical angles of corium. Ventral surface yellowish to white, sternum dusky. Legs white, femora with minute fuscous dots which form at base of certain pubescent hairs, one larger subapical spot on dorsal area; tibial spines with prominent black spots at base, claws black. Dorsum clothed with suberect, white pubescence, and intermixed with prostrate, silvery sericeous pubescence, some of which changes to pale golden on corium;

* Contribution from the Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

a tuft of black scales on corium at apex of clavus, also two or three smaller tufts of black scales along inner cuneal margin.

♀. Length, 2.6 mm., width, 1.08 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, June 11, 1924, Santa Catalina Mts., Arizona (A. A. Nichol); author's collection. *Allotype:* Same data as the type. *Paratypes:* 3 ♂, 3 ♀, taken with the types; found breeding on *Hyptis emoryi* by Mr. Nichol.

I take great pleasure in naming this beautiful little species after the collector, Mr. Andrew A. Nichol, who, in addition to being one of the Immortals at Bellou Wood, and still fighting to regain his health after being gassed in the war, is now proving himself an excellent collector and capable entomologist.

Parthenicus albellus new species.

Allied to *vaccini* V. D., but differs in the uniformly greenish white color, silvery white sericeous pubescence, with a tuft of black scales on corium at apex of clavus, and in the conspurcate membrane.

♂. Length 2.8 mm., width .97 mm. Head: width .54 mm., vertex .26 mm. Rostrum, length 1.2 mm., reaching upon base of genital segment. Antennæ: segment I, length .18 mm., pale greenish, a transverse fuscous mark on dorsal surface at slightly beyond middle; II, .84 mm., pale, dorsal surface narrowly fuscous at base, also a spot situated at middle of basal half; III, .60 mm.; IV, .31 mm., dusky. Pronotum: length .34 mm., width at base .83 mm. Pale whitish, tinged with green on head, pronotum, and ventral surface; membrane white, thickly conspurcate with fuscous marks which coalesce more or less to form larger irregular spots, the largest dark spot on margin near apex, while a smaller one occurs just beyond apex of cuneus; veins white. Legs white, femora with pale fuscous dots and marks; tibiæ with fuscous spot at base of each spine, but spots nearly obsolete on hind pair. Dorsum clothed with simple, suberect pale pubescence, longest on head, margins of pronotum, and costal margins; intermixed with prostrate, silvery sericeous pubescence, with a few pale golden yellow sericeous hairs on corium; a tuft of black scales on corium at apex of clavus, also a few darker scales at middle of inner margin of cuneus.

♀. Length 2.6 mm., width 1.08 mm.; more robust than the male with costal margin slightly arcuate, but very similar in pubescence and coloration.

Holotype: ♂, October 21, 1924, Pima Co., Arizona, (A. A. Nichol); author's collection. *Allotype:* Same data as the type. *Paratypes:* 7 ♂ ♀, taken with the types.

Parthenicus selectus new species.

Allied to *nicholi*, but differs in having discal area of membrane uniformly white and in lacking the orange red color bordering anal area; pronotal disk and hind femora with a few red dots; antennal segment II with obsolete fuscous dots.

♂. Length 3.5 mm., width 1.36 mm. *Head:* width .60 mm., vertex .26 mm. Rostrum, length 1.17 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .21 mm.; II, .94 mm.; III, .60 mm.; IV, .31 mm.; segment II with two or three obsolete fuscous dots near base, not distinctly marked with several black spots as in *nicholi* or *vaccini*. Pronotum: length .41 mm., width at base, 1 mm. Coloration very suggestive of *nicholi*, but ground color paler white; membrane uniformly white on disk, having only two fuscous areas each side on the margin; pronotal disk anteriorly, vertex, and hind femora bearing reddish dots, the femora also with fuscous points on apical half. Dorsum clothed with simple white pubescence as in *nicholi*, but more thickly intermixed with prostrate, golden and silvery sericeous pubescence, without black scales behind apex of clavus, although with dark bronze colored scales there and along inner margin of cuneus; basal half of scutellum with a few blackish scales each side mixed in with silvery sericeous pubescence.

Holotype: ♂, April 19, 1924, Tucson, Arizona, (A. A. Nichol); author's collection. *Paratypes:* 2 ♂, taken with the type. ♂, June 7, 1924, Tucson, Arizona, (A. A. Nichol).

Parthenicus pictus new species.

Allied to *giffardi* V. D., but size smaller, differs in the deeply colored roseate cuneus and apical area of corium, and by the silvery and golden sericeous pubescence.

♂. Length 2.9 mm., width 1.1 mm. Head: width .63 mm., vertex .23 mm. Rostrum, length 1.08 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .18 mm.; II, 1.03 mm.; III, .64 mm.; IV, .33 mm.; pale greenish, last two segments dusky. Pronotum: length .46 mm., width at base .91 mm. Head, pronotum, and body beneath green, sternum, vertex, and sometimes on pronotal disk, yellowish; basal two-fifths of clavus and corium, scutellum and apical angle of corium roseate red, scutellum darker; apical half of clavus pale yellowish, apical half of corium pale fuscous. Membrane uniformly dark fuscous, slightly paler bordering cuneus, veins bright red. Dorsum clothed with prostrate, silvery sericeous pubescence; apical half of clavus except apex, clothed with golden sericeous pubescence, corium with inner apical edge, point on middle and one at basal angle of inner margin of cuneus, set with fuscous to golden scale-like pubescence, also a few similar hairs on scutellum; hemelytra with sparsely set fuscous

pubescent hairs intermixed with the sericeous pubescence, the simple hairs being more prominent and silvery white on head and anterior margin of pronotum. Legs green, apical half with red and fuscous markings over a paler ground; tibiæ pale, with fuscous points at base of spines, hind pair with red points on basal two-fifths; tarsi dusky. Genital claspers tinged with red, form very near that of *psalliodes* Reuter.

♀. Length 2.8 mm., width 1.07 mm. Head: width .57 mm., vertex .31 mm. Antennæ: segment I, length .18 mm.; II, .93 mm.; III, .64 mm.; IV, .34 mm. Slightly more robust than the male, but very similar in coloration.

Holotype: ♂, September 25, 1924, Santa Catalina Mts., Arizona (A. A. Nichol); author's collection. *Allotype:* August 19, 1924, Sierrita Mts., Arizona (A. A. Nichol). *Paratypes:* 3♂, 1♀, taken with the allotype. ♀, June 15, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol). ♀, October 21, 1924, Pima Co., alt. 3,000 ft., Arizona (A. A. Nichol). ♀, July 16, 1917, Post Creek Canyon, Bonita, Arizona (H. H. Knight). ♂, ♀, July 20, 1917, Texas Pass, Arizona (H. H. Knight).

Parthenicus oreades new species.

Allied to *giffardi* V. D., but differs in the golden sericeous pubescence on clavus and corium, and in the red dotted pronotal disk with similar dotted area on middle of corium opposite apical area of clavus.

♂. Length 3.7 mm., width 1.28 mm. Head: width .66 mm., vertex .28 mm. Rostrum, length 1.07 mm., reaching upon fourth or fifth ventral segments. Antennæ: segment I, length .34 mm.; II, 1.14 mm.; III, .73 mm.; IV, .34 mm.; pale, segment I with a few minute flecks of red, apical segment scarcely dusky. Pronotum: length .51 mm., width at base 1.11 mm. Dorsum pale whitish, pronotal disk flecked with reddish, more thickly and with coalescing areas at sides; scutellum dark red, tip pale; clavus red at base for nearly length of scutellum, but edges breaking into dots; narrow base of corium and embolium, area on corium which includes apex of clavus, dotted with irregular flecks of red; inner apical angles of corium red, inner basal angles of cuneus thickly flecked with red. Membrane uniformly fuscous, a small clear spot by apex of cuneus; veins red, bordering apex of areoles white. Dorsum clothed with prostrate, silvery sericeous pubescence, clavus except base and apex, and corium largely except area surrounding apex of clavus, clothed with golden yellow sericeous pubescence; a smaller area at inner apical angles of corium as well as disk of scutellum, set with golden and blackish sericeous pubescence; head and margins of pronotum set with prominent white to yellow hairs. Head with sides and tylus chiefly red; sides of thorax reddish to fuscous, venter flecked with red on

the sides. Legs pale yellowish, femora with red, hind pair chiefly red, but broken by minute whitish reticulations; tibiæ with red dots at base of spines, becoming obsolete on apical half.

♀. Length 3.3 mm., width 1.28 mm. Head: width .63 mm., vertex .36 mm. Antennæ segment I, length .20 mm.; II, 1.03 mm.; III, .70 mm.; IV, .36 mm. Pronotum: length .48 mm., width at base 1. mm. Slightly more robust than the male, but very similar in coloration.

Holotype: ♂, July 18, 1917, Gowdy Creek Canyon, alt. 4,500 ft., Bonita, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* ♂, ♀, taken with the types. ♂, ♀, June 15, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol).

Parthenicus micans new species.

Suggestive of *oreades*, but size smaller, distinguished by the uniformly silvery white, scale-like pubescence on clavus and corium, with golden scale-like hairs only at inner apical angles of corium.

♂. Length 2.7 mm., width 1.14 mm. Head: width .63 mm., vertex .26 mm. Rostrum, length 1.06 mm., reaching upon fourth ventral segment. Antennæ: segment I, length .18 mm.; II, .86 mm.; III, .57 mm.; IV, .31 mm., uniformly pale yellowish, scarcely dusky on last segment. Pronotum: length .43 mm., width at base .88 mm. Dorsum creamy white, cuneus more strongly yellow and flecked with bright red, sometimes nearly all red; lateral margins of pronotum, base of corium, and frequently base of clavus, flecked with red, sometimes with a few scattering flecks of red on middle of corium; head yellowish and tinged with red. Dorsum clothed with prostrate, silvery white, scale-like pubescence, scutellum with spot each side on basal half clothed with bronze-colored scale-like hairs, inner apical angles of corium clothed with bronze to golden scale-like hairs which continue along inner margin of cuneus, but with a few blackish scales at two points; whole dorsum intermixed with nearly erect pale pubescent hairs, but more prominent on head, margins of pronotum and hemelytra. Membrane uniformly fusco-brownish, a pale spot bordering apex of cuneus; veins bright red, a white spot at apex of larger areole. Legs pale to yellowish, femora with small red dots on apical half, hind pair thickly dotted with red to fusco-reddish; tibiæ pale, with red dots at base of spines, but becoming obsolete on apical half, spines white, prominent, length of those near base equal to three times diameter of tibia. Sides of thorax and venter yellowish, dorsal half of propleura more or less red, sometimes the red showing on meso- and metapleura; venter pale pubescent, sides clothed with silvery white, scale-like pubescence.

♀. Length 2.6 mm., width 1.13 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 21, 1917, Santa Cruz river, Tucson, Arizona (H. H. Knight), collected at light; author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* 4 ♂, 4 ♀, taken with the types at light. 2 ♀, June 7, 1924, Tucson, Arizona (A. A. Nichol). ♀, July 20, 1917, Texas Pass, Arizona (H. H. Knight). ♀, July 2, 1917, Sabinal, Texas (H. H. Knight).

Parthenicus irroratus new species.

Size and color nearest to *psalliodes* Reut., but distinguished from all described species by the fuscous membrane with numerous white irrorate spots.

♂. Length 3.6 mm., width 1.03 mm. Head: width .61 mm., vertex .23 mm.; tylus very prominent, distinctly compressed. Rostrum, length .98 mm., just about attaining posterior margins of hind coxæ. Antennæ: segment I, length .27 mm.; II, .93 mm.; III, .74 mm.; IV, .33 mm.; pale yellowish and marked with reddish, segment I flecked with red, while segment II is more or less broadly tinged with red on apical half. Pronotum: length .43 mm., width at base .90 mm. Color pale testaceous and tinged with greenish, dorsum rather evenly flecked with reddish much as in *psalliodes,* cuneus darker on basal half; membrane fuscous, rather numerously marked with irrorate white spots, largest spots little greater than diameter of tibia. Dorsum clothed with suberect, simple, pale pubescence, longest on head and margins of pronotum; intermixed with golden and silvery pubescence, inner apical angles of corium and two points along inner margin of cuneus set with a few black scales; the fuscous basal half of scutellum also with a few dark scales. Sternum fuscous, pleura and coxæ greenish, venter greenish and rather thickly flecked with red. Femora marked with fuscous and fusco-reddish, the black marks and dots showing most clearly on dorsal aspect of apical half of hind femora, the ventral surface flecked with red; tibiæ pale, with red spots at base of spines.

♀. Length 2.9 mm., width 1.03 mm.; shorter and slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, March 22, 1924, Tucson, Arizona (A. A. Nichol); author's collection. *Allotype:* July 16, 1917, Post Creek Canyon, Bonita, Arizona (H. H. Knight), collected at light.

Parthenicus rubrinervis new species.

Distinguished by the uniformly yellowish or greenish yellow color, pale pubescence, and pale fuscous membrane with bright red veins.

♂. Length 2.7 mm., width 1.1 mm. Head: width .66 mm., vertex .19 mm. Rostrum, length 1.11 mm., only slightly exceeding posterior margins of hind coxæ. Antennæ: segment I, length .20 mm.; II, .97 mm.; III, .57 mm.; IV, .32 mm.; uniformly pale yellowish. Pronotum: length .43 mm.; width at base .86 mm. Pale yellowish to greenish yellow, eyes reddish; membrane uniformly light fuscous, veins bright red; clothed with silvery white, sericeous or scale-like pubescence, two points on inner margin of cuneus with black scale-like hairs; the whole dorsum also clothed with longer, more erect, pale yellowish pubescent hairs. Legs pale yellowish, femora with minute pale fuscous ring around base of each hair; tibiæ with obscure fuscous spot at base of each spine; tarsi pale, claws black. Genital claspers distinctive, right clasper terminating with a slender acuminate point at apex of dorsal margin.

♀. Length 2.7 mm., width 1.17 mm.; slightly more robust than the male, but similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Same data as type. *Paratype:* ♂, taken with the types.

Parthenicus baccharidis new species.

Allied to *psalliodes* Reut., but distinguished by the general pale color, impunctate hind tibiæ, although with minute fuscous dots on hind femora; silvery pubescent, but with golden sericeous pubescence on clavus and corium.

♂. Length 2.7 mm., width 1.03 mm. Head: width .63 mm., vertex .23 mm. Rostrum, length 1 mm., scarcely exceeding posterior margins of hind coxæ. Antennæ: segment I, length .20 mm.; II, .88 mm.; III, .63 mm.; IV, .33 mm. Pronotum: length .43 mm., width at base .86 mm. Color pale testaceous white, eyes reddish, basal half of scutellum slightly darkened, also dusky at inner apical angles of corium; membrane uniformly pale fuscous, veins pale, two orange flecks on apex of areoles. Femora with minute fuscous dots, one at base of each pubescent hair, obsolete ventrally; intermediate femora with reddish marks appearing on ventral surface; tibiæ pale, with fuscous dots at base of spines except on hind pair. Clothed with pale to yellowish simple pubescence, intermixed with more thickly set, prostrate, silvery sericeous pubescence, clavus except base and apex, corium, and cuneus, set with golden sericeous pubescence; inner apical angles of corium and inner margin of cuneus set with bronze to dusky scale-like pubescence. Genital claspers very similar to those of *psalliodes* Reuter.

♀. Length 2.7 mm., width 1.08 mm. Head: width .57 mm., vertex .28 mm. Antennæ: segment I, length .18 mm.; II, .91 mm.; III, .60 mm.; IV, .31 mm. Pronotum: length .40 mm., width at base .86 mm. Similar to the male in pubescence and coloration.

Holotype: ♂, July 23, 1917, Sabino Canyon, Alt. 3,000 ft., Tucson, Arizona (H. H. Knight); author's collection. *Allotype:* Same data as the type. *Paratypes:* ♂, 4 ♀, taken with the types and found breeding on *Baccharis emoryi.*

Parthenicus rubromaculosus new species.

Allied to *psalliodes* Reut., but size smaller; differs in the densely red-flecked hemelytra combined with nearly pale pronotum; inner apical angles of corium without fuscous or dark pubescence.

♂. Length 2.5 mm., width 1 mm. Head: width .57 mm., vertex .27 mm. Rostrum, length 1.11 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .18 mm.; II, .80 mm.; III, .57 mm.; IV, .31 mm.; pale yellowish, last two segments dusky. Pronotum: length .40 mm., width at base .86 mm. Head and pronotum pale to yellowish, head and margins of pronotum obsoletely flecked with reddish yellow; scutellum and hemelytra densely flecked with light red, the flecks coalescing to form larger irregular spots; cuneus thickly flecked like the corium, but with brighter red. Membrane fusco-brownish, paler bordering cuneal margin, veins bright red, a pale point at apex of larger areole. Dorsum clothed with pale to yellowish simple pubescence, intermixed with silvery sericeous pubescence, but chiefly golden sericeous pubescence on hemelytra; inner margin of cuneus with point at middle and one at base with a few darker scale-like hairs. Legs yellowish, femora flecked with red points, the hind pair with numerous minute pale fuscous points, one at base of each pubescent hair; tibial spines pale, with red points at base, although nearly obsolete on hind pair.

♀. Length 2.5 mm., width 1.11 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type at light; Cornell University collection. *Paratypes:* 8 ♂ ♀, taken with types. ♂, August 29, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol).

Parthenicus rufusculus new species.

Allied to psalliodes Reut., but size slightly larger; distinguished by the general fusco-reddish coloration.

♂. Length 3.6 mm., width 1.43 mm. Head: width .71 mm., vertex .23 mm. Rostrum, length 1.29 mm., reaching upon the fourth ventral segment, reddish orange, fuscous apically. Antennæ: segment I, length .21 mm.; II, 1.08 mm.; III, .61 mm.; IV, broken; yellowish with

a tinge of reddish, rather uniformly clouded by fuscous. Pronotum: length .53 mm., width at base 1.17 mm. Coloration fusco-reddish, an orange red hypodermal color clouded over by fuscous, cuneus more distinctly red, scutellum distinctly blackish, in darkest specimens the dorsum rather uniformly fuscous, which nearly obscures the reddish; thorax and coxæ rather uniformly fuscous, venter greenish yellow and darkened with fuscous. Legs greenish yellow to reddish, femora darkened by numerous small fuscous points, one such spot at base of each pubescent hair; tibial spines yellowish, a fuscous point at base of each. Membrane uniformly fuscous, a narrow pale area at apex of cuneus; veins orange red, a pale point on apex of larger areole. Dorsum clothed with prostrate, golden yellow sericeous or scale-like pubescence, some turning to black at inner apical angles of corium and along inner margin of cuneus, the whole dorsum more sparsely clothed with suberect, simple yellowish pubescence.

♀. Length 3.4 mm., width 1.2 mm. Head: width .63 mm., vertex .31 mm. Antennæ: segment I, length .17 mm.; II, .87 mm.; III, .58 mm.; IV, .33 mm. Pronotum: length .46 mm., width at base 1 mm. Shorter and slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, April 5, 1924, Tucson, Arizona (A. A. Nichol); author's collection. *Allotype:* Same data as type. *Paratypes:* ♂, February 9, 2 ♀, February 16, ♀ April 5, ♀ April 12, 1924, Tucson, Arizona, (A. A. Nichol).

Parthenicus aureosquamis new species.

Evidently most closely related to *percroceus* V. D., but differs in the golden, scale-like pubescence of the dorsum; veins of membrane red, their apex white; femora with fine pale fuscous dots, these spots becoming reddish on ventral surface.

♂. Length 2.8 mm., width 1.08 mm. Head: width .66 mm., vertex .24 mm. Rostrum, length, 1.14 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .20 mm.; II, .86 mm.; III, .54 mm.; IV, .27 mm.; yellow, sometimes tinged with reddish. Pronotum: length .43 mm., width at base .91 mm. Color reddish yellow to orange red, in darkest specimens the hemelytra except embolium becoming strongly red; scutellum slightly darker than clavus. Membrane uniformly fuscous, veins red, a white point at apex of areoles. Dorsum clothed with golden yellow simple pubescence, intermixed with thickly set, prostrate, sericeous and scale-like golden pubescence, membrane margin and a tuft at inner apical angles of corium, set with darker scale-like pubescence; a transverse area across apex of clavus and reaching middle of corium, inner basal angles of cuneus, claval margins of scutellum, and anteriorly on pronotum, set with silvery scale-like pubescence. Ventral surface and legs yellowish to reddish

yellow, hind femora darkened with numerous, minute pale fuscous points; tibial spines yellowish, a fuscous spot at base of each, becoming obsolete on hind tibiæ.

♀. Length 2.7 mm., width .86 mm.; more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* 22 ♂ ♀, taken with the types at trap light. ♂, July 16, 1917, Post Creek Canyon, Bonita, Arizona, (H. H. Knight). 8 ♂ ♀, June 7, 1924, Tucson, Arizona, (A. A. Nichol), on *Covillea* sp. ♂, July 21, 1917, between Texas Pass and Tucson, Arizona, (H. H. Knight), on *Covillea* sp. 5 ♂, July 13, 1917, Lordsburg, New Mexico, (H. H. Knight), at light. ♂, July 28, 1914, El Paso, Texas, (J. C. Bradley).

Parthenicus rufivenosus new species.

Distinguished from all other described species by the bright green hemelytra with fuscous membrane and red veins.

♀. Length 3.4 mm., width 1.34 mm. Head: width .66 mm., vertex .37 mm. Rostrum, length 1.21 mm., extending slightly beyond hind margins of posterior coxæ. Antennæ: segment I, length .28 mm.; II, 1.10 mm.; III, .77 mm.; IV, .38 mm.; greenish yellow, last segment dusky. Pronotum: length .51 mm., width at base 1.01 mm. Color greenish yellow, hemelytra and basal half of pronotum bright green, inner margin of cuneus bordering smaller areole bright red; membrane uniformly fuscous, slightly paler bordering apex of cuneus, veins bright red. Dorsum clothed with prostrate, silvery and dark bronze, sericeous pubescence, and intermixed with pale, more erect simple pubescence. Legs and ventral surface uniformly greenish yellow, tibiæ impunctate.

♂. Length 3.3 mm., width 1.26 mm. Similar to the female in pubescence and coloration. Antennæ and one wing mutilated in this specimen. Genitalia distinctive, the right clasper V-shaped, the apical half slightly more slender than basal half, slightly flattened and acuminate at tip.

Holotype: ♀, July 18, 1917, Gowdy Creek Canyon, Bonita, Arizona, (H. H. Knight); author's collection. *Allotype:* ♂, June 15, 1924, Santa Rita Mts., Arizona, (A. A. Nichol); author's collection. *Paratypes:* ♀, taken with type. ♀, taken with the allotype.

Parthenicus cuneotinctus new species.

Aspect of *rufivenosus*, but paler green in color; veins in membrane pale and spotted with red, cuneus broadly tinted with roseate-red; tibial spines with fuscous spots at base.

♀. Length 2.6 mm., width 1.06 mm. Head: width .56 mm., vertex .34 mm. Rostrum, length 1.04 mm., reaching to fifth ventral segment. Antennæ: segment I, length .20 mm.; II, .83 mm.; III, .54 mm.; IV, .31 mm. Pronotum, length .40 mm., width at base .91 mm. Color pale green, obsoletely maculated with pale yellow; head, anterior margin of pronotum, scutellum, and embolium, paler. Cuneus largely tinted with roseate-red. Membrane pale fuscous, paler within areoles and at apex of cuneus; veins pale to white, flecked with red. Pale pubescent, more densely clothed with prostrate, silvery scale-like pubescence; area on middle of corium and clavus, and inner apical angles of corium, clothed with golden scale-like pubescence, a few darker scales forming a point at middle of inner margin of cuneus and on basal angle. Ventral surface pale to greenish, venter pale pubescent and intermixed with silvery scale-like pubescence. Legs pale greenish, apical half of hind femora with pale yellow showing at base of pubescent hairs, a few obsolete or pale fuscous points on dorsal surface; tibial spines pale with fuscous spot at base of each, the spots more brownish on hind pair.

Holotype: ♀, August 19, 1924, Sierrita Mts., Arizona, (A. A. Nichol); author's collection. Mr. Nichol found this specimen on *Croton corymbulosus*.

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1924.*

JOHN H. SCHAFFNER
Department of Botany, Ohio State University

The following list of species is based on specimens presented to the Ohio State Herbarium during the past year and not only adds a number of species new to the state, but extends our knowledge of local distribution materially. Mr. Len. Stephenson has contributed an interesting collection from a locality known locally as "Buffalo Beat," near Buchtel, Athens County.

39a. *Polystichum acrostichoides schweinitzii* (Beck) Small. Buchtel, Athens Co. Len. Stephenson.

55. *Equisetum silvaticum* L. Wood Horsetail. "In a marshy woodland" south of Harpersfield, Ashtabula Co. Arthur R. Harper.

70. *Pinus virginiana* Mill. Scrub Pine. Ten miles east of West Union, Jefferson Twp., Adams Co. John H. Schaffner and C. K. Kao.

121. *Typha angustifolia* L. Narrow-Leaf Cat-tail. Buchtel, Athens Co. Len. Stephenson.

139.1. *Cyperus ovularis* (Mx.) Torr. Globose Cyperus. "Grassy swale," along Higby Pike, Pike Co. Arthur R. Harper.

158. *Stenophyllus capillaris* (L.) Britt. Hair-like Stenophyllus. East of Barnesville, Belmont Co. Emma E. Laughlin.

265. *Carex haydeni* Dew. Hayden's Sedge. Castalia, Erie Co. E. L. Moseley.

328. *Poa autumnalis* Muhl. Flexuous Spear-grass. Along Clear Creek, between Sugar Grove and Rock Bridge, just within Hocking Co. James S. Hine.

337. *Eragrostis purshii* Schrad. Pursh's Love-grass. East of Barnesville, Belmont Co. Emma E. Laughlin.

340. *Eragrostis capillaris* (L.) Nees. Capillary Love-grass. East of Barnesville, Belmont Co. Emma E. Laughlin.

---

* Papers from the Department of Botany, The Ohio State University, No. 157.

361. *Lolium multiflorum* Lam. Awned Darnel. Clifton, Greene Co. Arthur R. Harper.

384. *Sporobolus vaginaeflorus* (Torr.) Wood. Sheathed Rush-grass. "Wayside," Barnesville, Belmont Co. Emma E. Laughlin.

404. *Muhlenbergia tenuiflora* (Willd.) B. S. P. Slender Muhlenbergia. Washington Twp., Highland Co. Katie M. Roads.

411. *Aristida oligantha* Mx. Few-flowered. Triple-awned-grass. "Roadside between Lore City and Old Washington," Guernsey Co. Emma E. Laughlin.

412. *Aristida gracilis* Ell. Slender Triple-awned-grass. "Edge of woods," south of Barnesville, Belmont Co. Emma E. Laughlin.

428. *Panicum depauperatum* Muhl. Starved Panic-grass. "Edge of dry wood." Washington Twp., Highland Co. Katie M. Roads.

448a. *Panicum boscii molle* (Vas.) Hitch. & Ch. Bosc's Panic-grass. Washington Twp., Highland Co. Katie M. Roads.

471a. *Andropogon scoparius* Mx. Little Bluestem. Extremely white glancous variety. Jefferson Twp., Adams Co. John H. Schaffner.

504. *Trillium declinatum* (Gr.) Gleason. Drooping Trillium. "Edge of woods." Liberty Twp., Highland Co. Martha J. Mercer and Katie M. Roads. Also near Belfast, Jackson Twp., Highland Co. Martha J. Mercer.

532.1. *Commelina communis* L. Asiatic Day-flower. Buchtel, Athens Co. Len. Stephenson.

545. *Juncus torreyi* Cov. Torrey's Rush. Barnesville, Belmont Co. Emma E. Laughlin.

577. *Blephariglottis lacera* (Mx.) Farw. Ragged Fringed-orchis. Minford, Scioto Co. Arthur R. Harper.

580. *Blephariglottis peramoena* (Gr.) Rydb. Fringeless Purple Orchis. Piketon, Pike Co. Arthur R. Harper.

587. *Ibidium plantagineum* (Raf.) House. Broadleaf Lady's-tresses. Cedar Swamp, Champaign Co. Arthur R. Harper.

619. *Ranunculus obtusiusculus* Raf. Lance-leaf Buttercup. Gallipolis, Gallia Co. Arthur R. Harper.

657. *Berberis vulgaris* L. Common Barberry. In the original catalog (1914) this plant was said to be "Escaped rather generally." According to John W. Baringer, State Leader of barberry eradication in Ohio, barberry has been planted here and there, both in towns and in the country, all over Ohio. In the northwestern two-thirds of the state, which has been covered by the barberry eradication survey, it has been found as an escape, often abundant, in nearly all of the counties. Local botanists should assist as much as possible in educating the public on the importance of eliminating this undesirable plant from the state.

658. *Odostemon aquifolium* (Pursh) Rydb. Trailing Mahonia. Near Richfield, Summit Co. Introduced in some unknown way. Now eradicated.

667. *Papaver dubium* L. Corn Poppy. Along B. & O. Railway, near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads.

687. *Camelina sativa* (L.) Crantz. Common False-flax. "A large patch along railway track" near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads. Also Barnesville, Belmont Co. Emma E. Laughlin.

688. *Camelina microcarpa* Andrz. Small-fruited False-flax. Hillsboro, Highland Co. Katie M. Roads.

690. *Neslia paniculata* (L.) Desv. Ball-mustard. Barnesville, Belmont Co. Emma E. Laughlin.

703. *Thlaspi arvense* L. Field Penny-cress. Barnesville, Belmont Co. Emma E. Laughlin.

708. *Cheirinia cheiranthoides* (L.) Link. Worm-seed Mustard. St. John's woods, Bowling Green, Wood Co. E. L. Moseley.

754. *Polanisia graveolens* Raf. Clammy-weed. Near Hillsboro, Highland Co. Katie M. Roads.

764. *Erodium cicutarium* (L.) L'Her. Hemlock Stork's-bill. Glen Mary, Franklin Co. Howard W. Johnson.

774.1. *Linum striatum* Walt. Ridged Flax. "In orchard" near Barnesville, Belmont Co. Emma E. Laughlin.

776. *Linum medium* (Planch.) Britt. Stiff Flax. Washington Twp., Highland Co. Katie M. Roads.

804. *Tithymalus peplus* (L.) Hill. Petty Spurge. "Persistent weed in an old garden." Somerton, Belmont Co. Emma E. Laughlin.

848. *Hypericum drummondii* (Grev. & Hook.) T. & G. Drummond's St. John's-wort. North of Lore City, Guernsey Co. Emma E. Laughlin.

849. *Sarothra gentianoides* L. Orange-grass. Union Twp., Scioto Co. John H. Schaffner.

875.1. *Viola cucullata* Ait. Marsh Blue Violet. Collected by Otto Hacker at Painesville, Lake County, in 1902. Determined by R. Crane.

892. *Moehringia lateriflora* (L.) Fenzl. Bluntleaf Moehringia. Liberty Twp., Wood Co. E. L. Moseley.

923. *Vacaria vacaria* (L.) Britt. Cowherb. "Along a railway track," near Hillsboro, Highland Co. Katie M. Roads.

925. *Dianthus armeria* L. Deptford Pink. Buchtel, Athens Co. Len. Stephenson. Also along Pond Lick Road, Scioto Co. Arthur R. Harper.

1016. *Drymocallis agrimonioides* (Pursh) Rydb. Mac-o-cheek Castle, Logan Co. Arthur R. Harper.

1017. *Waldsteinia fragarioides* (Mx.) Tratt. Dry Strawberry. "On the top edges of cliffs at Rocky Fork Caves." Paint Twp., Highland Co. Katie M. Roads.

1037. *Spiraea tomentosa* L. Steeple-bush. Oxford Twp., Erie Co. E. L. Moseley.

1116. *Trifolium arvense* L. Rabbit-foot Clover. Fairview, Guernsey Co. Mrs. T. S. Rosengrant. Also Guernsey Co. Fair Ground. Emma E. Laughlin. Also Gallipolis, Gallia Co. Arthur R. Harper.

1135. *Stylosanthes biflora* (L.) B. S. P. Pencil-flower. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1151. *Lespedeza repens* (L.) Bart. Creeping Bush-clover. "In a virgin forest" S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1160.1. *Lespedeza striata* (Thunb.) H. and A. Japan Bush-clover. In a meadow locally called "Buffalo Beat,"

Buchtel, Athens Co. "The Lespedeza forms a thick mat." Collected by Len Stephenson. Received from Freda Detmers, Ohio Agr. Exp. Sta., Wooster. Also near Portsmouth, Scioto Co. John H. Schaffner and C. K. Kao.

1161.1. *Vicia villosa* Roth. Hairy Vetch. Procterville, Lawrence Co. R. B. Gordon.

1181. *Sedum triphyllum* (Haw.) S. F. Gr. Live-forever. Lake Twp., Ashland Co. Also near Warren, Trumbull Co. John H. Schaffner.

1200. *Rhexia virginica* L. Virginia Meadow-beauty. Rarden, Scioto Co. Also present at Blue Creek, Adams Co. Conrad Roth.

1207. *Ceanothus americanus* L. Common New Jersey Tea. Washington Twp., Highland Co. Katie M. Roads.

1372. *Lysimachia quadrifolia* L. Whorled Yellow Loosestrife. Marshall Twp., Highland Co. Katie M. Roads.

1380a. *Anagallis arvensis coerulea* (Schreb.) Ledeb. Blue Pimpernel. "Edge of a waste lot," Hillsboro, Highland Co. Katie M. Roads.

1389. *Chimaphila maculata* (L.) Pursh. Spotted Pipsissewa. Washington Twp., Highland Co. Katie M. Roads.

1396. *Azalea viscosa* L. Swamp Azalea. Eliminate from the list. Alfred Rehder of Arnold Arboretum found that our specimen was incorrectly determined.

1420. *Phlox pilosa* L. Downy Phlox. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1433.1. *Convolvulus repens* L. Trailing Bindweed. On "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1434. *Convolvulus japonicus* Thunb. Japanese Bindweed. "A large and well-established area along the B. & O. S. W. railway to the north and west of Hillsboro," Liberty Twp., Highland Co. Katie M. Roads.

1448. *Hydrophyllum canadense* L. Broadleaf Water-leaf. Near Hillsboro, Highland Co. Katie M. Roads.

1469. *Gentiana flavida* Gr. Yellowish Gentian. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1481.1. *Asclepiodora viridis* (Walt.) Gr. Oblong-leaf Green Milkweed. "Limestone ravine," near Rarden, Adams Co. Arthur R. Harper.

1501.1. *Browallia demissa* L. Browallia. "Persistent after cultivation." Hillsboro, Highland Co. Katie M. Roads.

1504. *Physalis ixocarpa* Brot. Mexican Ground-cherry. "Three large plants growing along railroad switch." Barnesville, Belmont Co. Emma E. Laughlin.

1555. *Aureolaria flava* (L.) Farw. (Dasystoma virginica (L.) Britt.) Smooth False Foxglove. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson. Also "in a virgin forest" S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1568. *Chaenorrhinum minus* (L.) Lange. Lesser Toadflax. "Very common along railway tracks" near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads.

1570. *Kickxia elatine* (L.) Dum. Sharp-pointed Toadflax. St. Paris, Champaign Co. Ruth Rider.

1586. *Ruellia strepens* L. Smooth Ruellia. Buchtel, Athens Co. Len. Stephenson.

1600. *Lithospermum officinale* L. Common Gromwell. Cincinnati, Hamilton Co. O. T. Wilson.

1616. *Trichostema dichotomum* L. Blue-curls. Buchtel, Athens Co. Len. Stephenson.

1627. *Scutellaria integrifolia* L. Hyssop Skullcap. Procterville, Lawrence Co. R. B. Gordon.

1665.1. *Moldavica parviflora* (Nutt.) Britt. American Dragonhead. "On a vacant lot." Barnesville, Belmont Co. Emma E. Laughlin.

1701. *Aralia hispida* Vent. Bristly Sarsaparilla. Thompson's Ledge, Geauga Co. Arthur R. Harper.

1704. *Eryngium aquaticum* L. Rattlesnake-master. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1713.1. *Anethum graveolens* L. Dill. "In a waste lot." "Persistent after cultivation." Hillsboro, Highland Co. Katie M. Roads.

1753.1. *Houstonia lanceolata* (Poir.) Britt. Calycose Houstonia. "In a wood." Washington Twp., Highland Co. Katie M. Roads.

1760. *Diodia teres* Walt. Rough Buttonweed. Buchtel, Athens Co. Len. Stephenson.

1760.1. *Galium vernum* L. Yellow Bedstraw. "Clay bank on the National Road, about four miles east of Cambridge," Guernsey Co. Emma E. Laughlin.

1764. *Galium boreale* L. Northern Bedstraw. Margaretta Ridge, Erie Co. H. C. Schoepfle. Presented by E. L. Moseley.

1802. *Diervilla diervilla* (L.) MacM. Bush-honeysuckle. Thompson's Ledge, Geauga Co. Arthur R. Harper.

1819. *Lobelia leptostachys* A. DC. Spiked Lobelia. "Banks of a small stream." Marshall Twp., Highland Co. Katie M. Roads. Also "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1830. *Heliopsis scabra* Dunal. Rough Oxeye. Hillsboro, Highland Co. Katie M. Roads.

1834. *Rudbeckia fulgida* Ait. Orange Cone-flower. Near Captina Creek, about eight miles S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1835. *Rudbeckia speciosa* Wend. Showy cone-flower. Jefferson Twp., Adams Co. John H. Schaffner.

1839. *Echinacea purpurea* (L.) Moench. Purple Cone-flower. "Edge of a dry rocky wood." Washington Twp., Highland Co. Katie M. Roads. Also "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1857. *Phaethusa helianthoides* (Mx.) Britt. Sunflower Crownbeard. "Frequent along roadsides," Scioto Co. Arthur R. Harper.

1886. *Helenium nudiflorum* Nutt. Purple-headed Sneezeweed. Dundas, Vinton Co. Arthur R. Harper.

1909. *Solidago erecta* Pursh. Slender Goldenrod. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1912.1. *Solidago odora* Ait. Sweet Goldenrod. Roosevelt Forest Preserve, Scioto Co. Conrad Roth.

1922. *Solidago rigida* L. Stiff Goldenrod. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1930. *Siricocarpus asteroides* (L.) B. S. P. Toothed Whitetop Aster. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1934. *Aster azureus* Lindl. Azure Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1942. *Aster phlogifolius* Muhl. Thinleaf Purple Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1947.1. *Aster concinnus* Willd. Narrowleaf Smooth Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1967. *Ionactis linariifolius* (L.) Greene. Stiffleaf Aster. McDermott, Scioto County. Conrad Roth.

1978. *Kuhnia eupatorioides* L. False Boneset. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1980. *Lacinaria cylindrica* (Mx.) Ktz. Cylindric Blazing-star. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1982. *Lacinaria scariosa* (L.) Hill. Large Blazing-star. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson. Also in Union Twp., Scioto Co. and Jefferson Twp., Adams Co. John H. Schaffner.

1988. *Elephantopus carolinianus* Willd. Carolina Elephant's-foot. Buchtel, Athens Co. Len. Stephenson.

1999. *Matricaria matricarioides* (Lees.) Port. Rayless Camomile. Barnesville, Belmont Co. Emma E. Laughlin.

2014. *Senecio pauperculus* Mx. Balsam Squaw-weed. Put-in-Bay, Ottawa Co. E. L. Moseley.

2026a. *Cirsium arvense integrifolium* Wimm. & Grab. North of Akron, Summit Co. C. J. Willard.

2029.2. *Centaurea nigra* L. Black Star-thistle. "Pasture-field" south of Barnesville, Belmont Co. Emma E. Laughlin.

2030.1. *Centauria solstitialis* L. Barnaby's Star-thistle. "In alfalfa field." Celina, Mercer Co., collected by Banks Collings. Specimens also sent to the Ohio Agr. Exp. Sta. at Wooster, from Fulton, Van Wert, and Ross counties. "From alfalfa fields, the plant probably being introduced with the alfalfa seed." Freda Detmers. Also Greenville, Darke Co. R. C. Smith.

2039. *Sonchus arvensis* L. Field Sow-thistle. Barnesville, Belmont Co. Emma E. Laughlin.

2043.1. *Lactuca sativa* L. Garden Lettuce. "Along railway track," near Hillsboro, Highland Co. Katie M. Roads.

2047. *Lactuca villosa* Jacq. Hairy-veined Blue Lettuce. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

2051.1. *Nabalus serpentarius* (Pursh) Hook. Lion's-foot (Rattlesnake-root). Buchtel, Athens Co. Len. Stephenson.

2054. *Nabalus crepidineus* (Mx.) DC. Corymbed Rattlesnake-root. Eight miles S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

2064.1. *Crepis biennis* L. Rough Hawksbeard. Buchtel, Athens Co. Len. Stephenson.

THE NATURAL VEGETATION OF OHIO.

PAUL BIGELOW SEARS
Department of Botany, The University of Nebraska

I. A Map of the Virgin Forest.

SOURCES UPON WHICH THE MAP IS BASED.

This map has been prepared by transcribing the species of bearing trees recorded by the original surveyors who traversed the Territory and State of Ohio before the destruction of the virgin forest by the hands of white men.

Surveying of Ohio was begun in July, 1786, (1) under The Geographer of the United States, Thomas Hutchins, employing for the first time his device of sections one mile square. This empirical device was hailed as a great American invention, although the State of Ohio has since been found to possess a curved surface in common with the rest of the earth. All corners which lay within the forest were located with reference to nearby trees, the species of which were noted. These corners becoming permanent, the net result of Hutchin's plan has been the preservation of a systematic record of such great biological value as to redeem its geometrical shortcomings.

Following the death of Hutchins, active surveying seems to have gone slowly until about 1796. The parcels into which the region was divided are shown in the sketch map, Fig. 1. The Virginia Military Bounty was never surveyed systematically, nor have records for the lower portion of the Symmes Purchase been at hand in usable form. Within the United States Military Bounty most townships were surveyed in part only. The portion of the Western Reserve between the Cuyahoga River and the west line of Lorain County was merely reconnoitered at the time of the first survey. The remainder of the Western Reserve, all of the Congress Lands, and the Seven Ranges were surveyed throughout, traverses in the Reserve being limited to township, rather than section lines as elsewhere. The records of the Western Reserve are still in manuscript form in the vaults of the Western Reserve Historical Society at Cleveland. They

form a document of great interest—sufficient, in fact, to have warranted the special publication of that part dealing with the "Firelands" (now Erie and Huron Counties) by the Firelands Pioneer of Norwalk. Records for the Ohio Company's Pur-

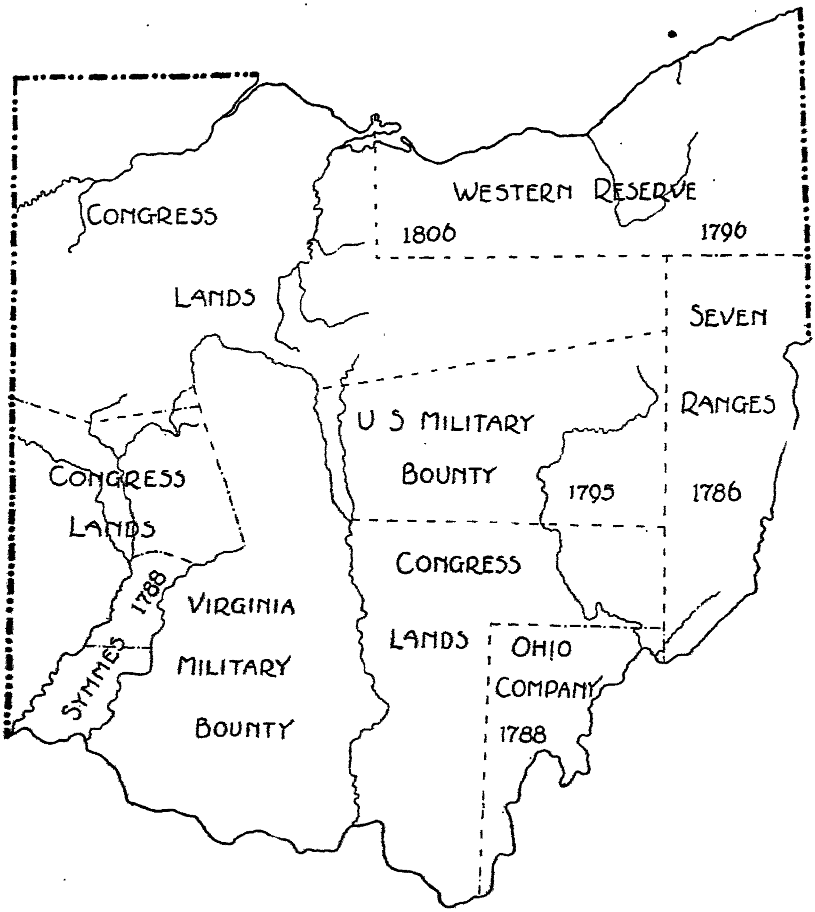


Fig. 1. Ohio Land Parcels.

chase are at Marietta. The remaining field notes are in the office of the Auditor of State at Columbus. Portions dealing with a given county are often copied and the copy filed in the county engineer's office.

For those districts whose record is lacking or incomplete, it has fortunately been possible to secure considerable information

from county histories, the earlier volumes of the geological survey, journals of travelers, verbal descriptions and other historical sources. Throughout all of the state except the southern and eastern portions the writer has frequently had opportunities to check the historical record against the present field conditions. The technique employed in transcribing and interpreting data has been described earlier, (2).

The writer is indebted to the Trustees of the Emerson McMillan Research Fund of the Ohio Academy of Science, and to Chancellor Samuel Avery, of the University of Nebraska for financial assistance in meeting the expenses of field work. For escape from many errors of judgment he must thank his former colleagues in botany at Ohio State University. Mrs. Marjorie McCutcheon Sears and Miss Helen Nott have helped greatly in transcription, the latter securing data on the Ohio Company's Purchase made available through the courtesy of the librarian of Marietta College.

Many other individuals have been of more than casual service—Captain Henry, of the State Auditor's Office, and Curator Cathcart, of Cleveland, to mention two. Moreover, the ready encouragement of Professor Henry C. Cowles has been invaluable.

HOW TO READ THE MAP.

Townships have been selected as convenient units for this map. Some are five, some six miles square, but in any case an effort has been made to generalize the forest type within each township. With few exceptions most townships have been classified as fundamentally "Beech," "Oak," or "Ash"—or various combinations of these types. The sense in which these three terms are employed must be clearly understood. The data at hand are involved, and it is only by being somewhat arbitrary that one can bring them all to rest peaceably upon a map of the present scale. (Fig. 2).

Beech, represented by a vertical cross, or plus mark, in most cases consisted of beech and sugar maple. Upon certain old upland flats and thin-soiled patches known as "scalded" or "thin" beech land, the sugar was absent. In typical beech-sugar maple a sprinkling of white ash and red oak was the rule. Unless their numbers were very large, however, no signs for oak and ash have been added in such cases.

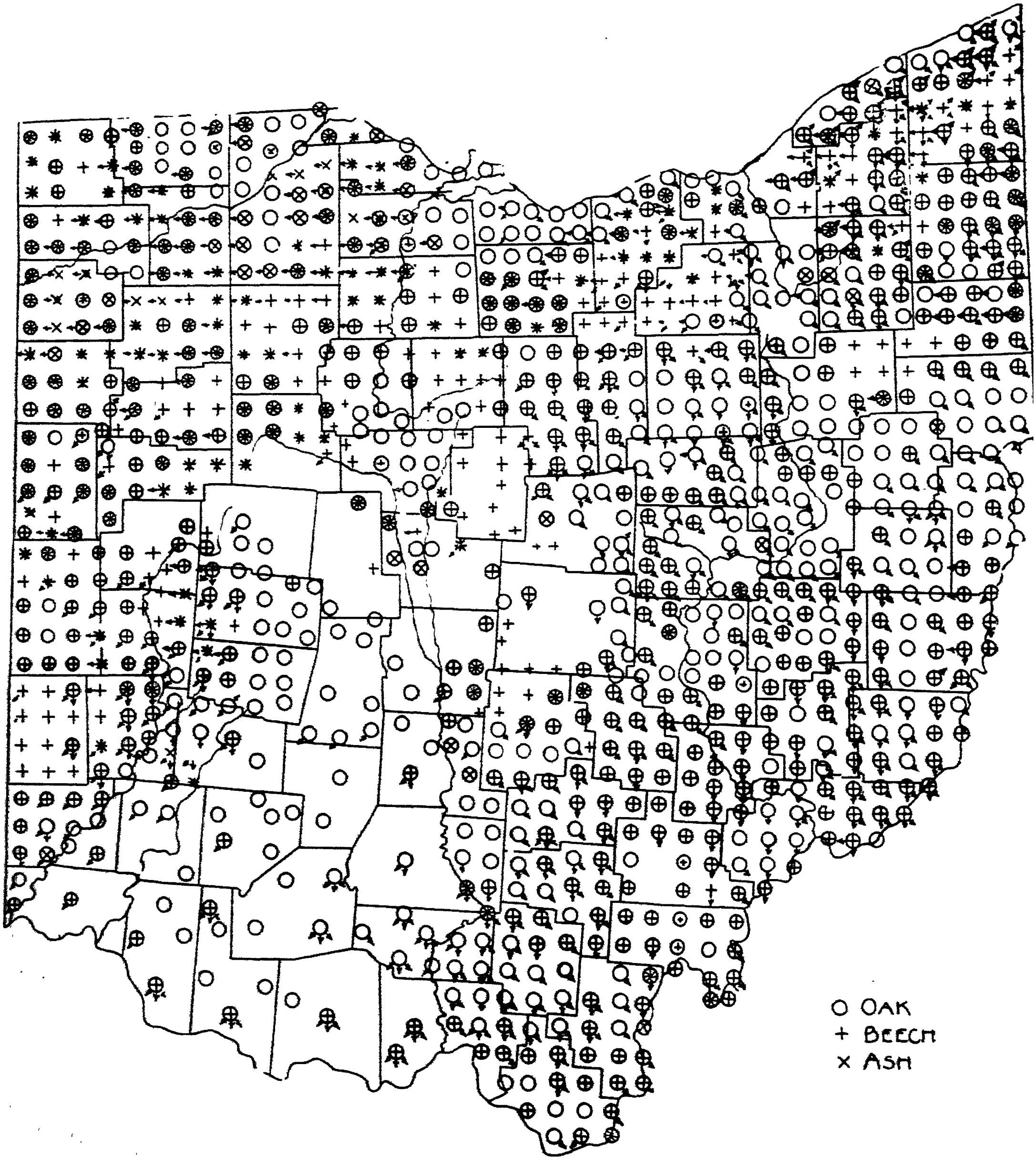


Fig. 2. Map of the Ohio Virgin Forest.

"Beech" designates pure stands of beech, also beech-maple with (often) more or less red oak and white ash.

"Oak" includes white oak, hickory, burr oak, black oak; also chestnut-chestnut oak.

"Ash" designates black ash—white ask, usually with elm, and often with red maple.

Arrows point toward the approximate present-day centers of distribution of species additional to the above. See text for further explanation of symbols.

Oak is represented by a circle. The most frequent grouping of oaks throughout the state was white oak, black oak, and hickory; with chestnut oak when chestnut was present; with burr oak (often scrubby) in many prairie habitats; with red oak in mixtures containing sugar maple and beech; and with other oaks chiefly in rather restricted conditions. At places, e. g. the lower Scioto valley, in mixtures with poplar, cherry, walnut, etc. "Oak" was mainly represented by hickory. This was unusual. The oak type, then, was primarily white oak—black oak—hickory with the qualifications above listed.

Ash is indicated by an X. Theoretically we should expect white ash to have been limited to the mesophytic beech-sugar maple association. Black ash on the other hand would be looked for principally in the colder and more youthful swamp forests. Actually, however, when much ash was present, black and white ash seem to have been so intermingled, along with elm and frequently soft maple, that the symbol for ash really indicates these four trees, in varying proportions.

Besides the trees designated by Oak, Ash, and Beech, other trees were found in significant numbers in many townships. To indicate these associated species arrows have been used upon the map.

Arrows pointing northeast indicate the presence of hemlock, white pine, or (as in southern Clarke County) arbor vitae. Some of the birches and alders found in Ohio ought to be included in this group, but unfortunately we cannot gather from the record whether northerly or southerly species were meant in any given case.

Arrows pointing southeast symbolize the following, easterly or southeasterly: chestnut, chestnut oak, scrub pine, and pitch pine.

Arrows pointing southward indicate one or more of these species: black cherry, cucumber magnolia, both gums (sweet gum or liquidamber and tupelo, pepperidge, sour or black gum—the latter being much more common), and tulip poplar.

Arrows pointing southwest indicate the presence of any of the following, to wit: buckeye (sweet and Ohio), dogwood, hackberry, sycamore, and black walnut. Of these the Ohio buckeye, sycamore and black walnut are perhaps more strictly southern than southwestern with respect to Ohio. Inasmuch, however, as all form a more or less coherent group whose center

of dispersal in Ohio is without question the southwestern corner of the state, the liberty taken is believed to be justified. (3).

Arrows pointing westward signify linden, ironwood, or cottonwood.

Treeless areas are not indicated upon the map, nor, generally, are such local details as restricted swamps. There were, for example, small stands of tamarack in Portage, Williams, and Defiance Counties which are not shown.

DISTRIBUTION OF THE CONSPICUOUS FOREST TREES.

Looking over the map as a whole it will be noted that Oak was the most ubiquitous type, with Beech second, and Ash distinctly third. All were found mixed more often than alone. The arrows pointing toward the range centers of associated species show a grouping, on the whole, such as one would normally expect.

The primary physiographic divisions of the state (4) are the Erie Plain and Alleghany Plateau. Glaciation, however, extended well beyond the plain into the plateau. The present drainage basin of Lake Erie does not coincide with the Erie Plain exactly, falling a little north of it at the West, and considerably south of it toward the East. A further important boundary seems to be that between the Carboniferous and Devonian, roughly making a vertical bisect of the state, turning east along the lake and a short distance west along the Ohio River. To the right of this line are mainly sandstones and shales, with some limestone, to the left of it mainly limestone and shales.

Summarizing, then, we get (Fig. 3):

AA—Erie Plain-Alleghany Plateau.
BB—Erie-Ohio Divide or Crestline.
CC—Carboniferous-Devonian Boundary.
DD—Glacial Boundary.

Certain facts with regard to the associated species (those indicated by arrows upon the map, Fig. 2) now become of interest.

Species from the West—ironwood, linden, cottonwood—were most common in the northwestern part of the state, within the Erie Plain, which here forms a broad shallow pass across Indiana and into the Mississippi Valley.

Southwestern species as we have here called them (buckeye, black walnut, hackberry, sycamore) were most numerous upon the glaciated Ohio Basin-Alleghany Plateau at the southwestern corner of the state. From that point they diverged eastward

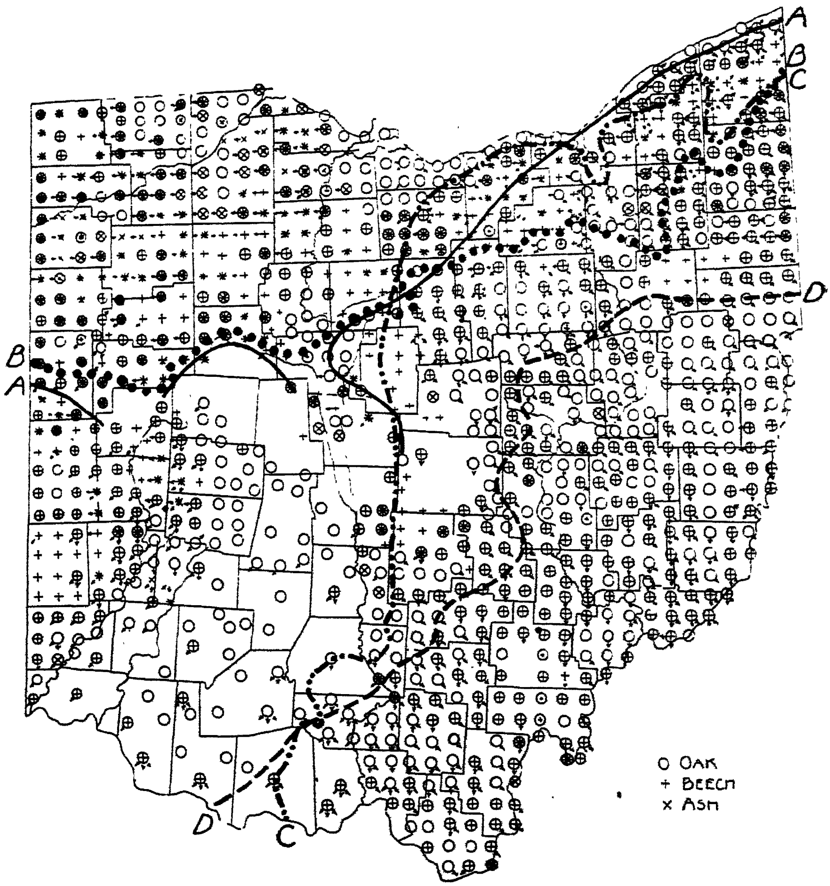


Fig. 3. Ohio Physiographic Boundaries.

A-A, Erie Plain-Alleghany Plateau; C-C, Carboniferous-Devonian Line;
B-B, Lake Erie-Ohio River Divide; D-D, Glacial Limit.

and northward along the Upper Ohio and its great tributaries, the two Miamis and the Scioto. Obviously, at the southwestern corner of the state the Ohio Valley itself forms a pass southwestward toward the lower Mississippi region.

Southeastern and southern forms—chestnut, chestnut oak, pitch pine, scrub pine, and cucumber, tulip, gums, cherry—were all found principally east of the Devonian boundary upon Carboniferous substratum and were upon the whole decidedly more conspicuous upon the unglaciated area than elsewhere. There were indeed groves of chestnut in Wood and Butler counties, (Fig. 4), but upon sandy soil in both instances. It scarcely needs to be pointed out that the unglaciated Alleghany Plateau, extending as it does without interruption on into the southern and southeastern Appalachians, constitutes a pass in the sense of a continuity of habitat.

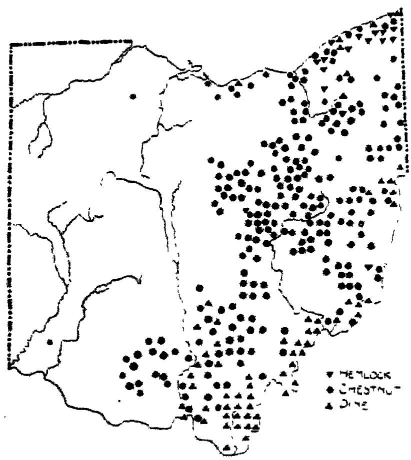


Fig. 4. Records of Hemlock, Chestnut and Pine in the Virgin Forest of Ohio.

Hemlock and white pine from the northeast were most abundant in the patch of glaciated Devonian at the northeast corner of the state (Fig. 4), but were found to some extent throughout the eastern half of the glaciated plateau lying north of the present Erie-Ohio Divide. They seem to have occupied rather deep and sheltered north-facing ravines which open out onto the lake. The arbor vitae swamp in southern Clarke County was an isolated outlier, comparable with the hemlock in Knox and Belmont counties.

Species from all directions—even a few from the southwest which had farthest to come—met and overlapped in a great focus or complex near the northeastern corner of Ohio. A

glance at the map, Fig. 3, shows clearly that here the physiographic boundaries approach most closely. It does not seem difficult to explain why the native forest here developed its greatest diversity.

Turning now from the various groups of associated species to the three characteristic groups, we note that:

Oak unmixed with Beech or Ash was found upon both glaciated and unglaciated areas;

Beech unmixed with Oak or Ash was practically limited to the glaciated region, while the unmixed Ash was still more restricted, being largely within the Erie Plain.

It will be recalled that the unglaciated area is a region of strong relief. Oak here occupied the exposed hilltops, with chestnut, chestnut oak, or pine. Beech was interspersed with southern mesophytes throughout the denser upland forests and in ravines. The virgin forest of the unglaciated region was not a homogeneous mixture, however, as Figs. 4 and 5 clearly show. The same conclusion has been reached by Schaffner (5) and Transeau (unpublished) working on different lines of evidence.

With respect to the glaciated region, certain broad general principles of distribution are recorded in Fig. 5. Here are shown the moraine system after Leverett (6) and the position of Beech and Oak. Mixtures of Beech and Oak have been omitted for the sake of clarity, as has Ash.

A comparison of Figs 3 and 5 makes it clear that Ash was most abundant upon certain broad intermorainal flats or depressions—i. e. of the ground moraine. This was especially true for the Erie Lobe (Black Swamp Region), although both the Scioto and Grand River Lobes show Ash similarly located.

Beech, it will be noted from Fig 5, was on the whole most abundant along the edges of the great glacial lobes. That is to say it occupied, if not always actual lateral moraines, at least the lateral regions of the ground and terminal moraines.

Oak, on the other hand, was found chiefly near the apex of each glacial arc, in that region where ground and terminal moraines intermingle. Such regions afford characteristic knob and kettle topography. The position of oak here was usually closely associated with swamp or wet prairie. It is important to remember, however, that oak did not occur in the actual depressions themselves. It grew upon the knobs which were elevated, often slightly, above the adjacent glacial puddles.

Oak was also found upon old beach dunes in Fulton and Lucas counties, upon limestone ridges near Sandusky Bay, eastward upon high exposed clay cliffs above Lake Erie, and elsewhere upon the tops of very high, exposed, although glaciated hills.

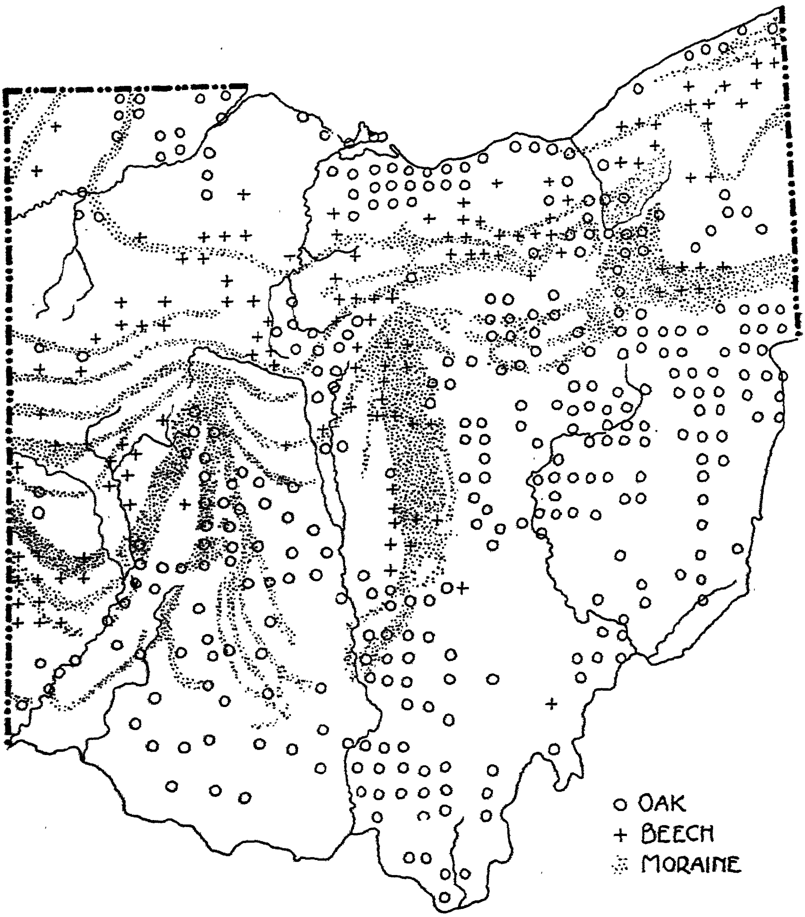


Fig. 5. Native Oak and Beech Forest in Relation to the Moraine System of Ohio.

SUMMARY AND CONCLUSIONS.

Deferring for the present the matter of plant succession we have the following general facts about the Ohio virgin forest.

1. The most characteristic species groups within the state were, first, Oak, (black oak—white oak—hickory, etc.); second,

Beech (beech—sugar maple, etc.); third, Ash (black ash—white ash—elm—maple, etc.). These groups were intermingled more often than not. Unmixed Beech was practically limited to the glaciated region. Ash was best developed within the Erie Plain.

2. The distribution of these characteristic species groups within the glaciated area was primarily correlated with the moraine system. Broadly speaking, Beech tended to appear along the sides, Ash upon the central ground, and Oak towards the central terminal region of the glacial lobes.

3. With these groups of species were associated others whose range centers lay outside of Ohio. By far the most widespread of these groups was the generally southerly one, comprising the Southeastern (chestnut, pine, etc.), Southern (cherry, gums, tulip, etc.), and Southwestern (buckeye, hackberry, etc.). A Western group (linden, cottonwood, etc.) was somewhat less extensive, while northerly groups—Northern (tamarack) and Northeastern (hemlock, white pine, etc.) were decidedly restricted.

3. The distribution of these associated species was correlated broadly with the fundamental physiographic boundaries within Ohio, i. e., Plateau-Plain, Crestline, Glacial Limit, and Carboniferous Escarpment.

4. The facts of distribution of species groups in the unglaciated area accord substantially with the recent, as yet unpublished, field studies of Transeau. He has correlated these facts with the surface geology.

LIST OF REFERENCES CITED.

1. Howe.
   Historical Collections of Ohio. Ohio Cent. Ed. 1:128–136. Columbus. 1908.
2. Sears, P. B.
   Vegetation Mapping. Science, N. S. 53:325–327. 1921.
3. Braun, E. L.
   Composition and Source of the Flora of the Cincinnati Region. Ecology 2:161–180. 1921.
4. Hubbard, G. D., Stauffer, C. R., Bownocker, J. A., Prosser, C. S., and Cummings, E. R.
   The Columbus Quadrangle. U. S. G. S. Folio 197.
5. Schaffner, J. H.
   A Preliminary Survey of Plant Distribution in Ohio. Ohio Naturalist 15:409–418. Maps I–III. 1915.
6. Coffey, G. N. et al.
   Reconnoissance Soil Survey of Ohio. Adv. Sheet, Field Op. Bureau of Soils, U. S. D. A. 1912. Plate C. 1915.

Date of Publication, May 19, 1925.

THE OHIO JOURNAL OF SCIENCE

VOL. XXV JULY, 1925 No. 4

REPORT OF THE THIRTY-FIFTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The Thirty-fifth Annual Meeting of the Ohio Academy of Science was held at the College of Wooster, Wooster, April 3 and 4, 1925, under the Presidency of Dr. Edgar N. Transeau. Something over one hundred members registered as in attendance; forty-six new members were elected, making a total membership at the close of the meeting of 396.

GENERAL PROGRAM.

FRIDAY, APRIL 3.

9:30 A. M.—Business Meeting.
10:30 A. M.—Reading of Papers in General Session.
1:30 P. M.—The Invitation Address by Prof. C. G. Williams, Director Ohio Agricultural Experiment Station, Wooster, on "The Work of the Ohio Agricultural Experiment Station."
2:30 P. M.—Reading of Papers in Sectional Meetings.
6:30 P. M.—Annual Banquet, Kenarden Lodge, followed by an address of welcome by President C. F. Wishart of The College of Wooster.
8:00 P. M.—Address by President Transeau, Taylor Hall, on "Accumulation of Energy by Plants."

SATURDAY, APRIL 4.

8:00 A. M.—Adjourned Business Meeting.
9:00 A. M.—Reading of Papers in General Session.
10:30 A. M.—Inspection of Orchards and Horticultural Work at The Ohio Agricultural Experiment Station under leadership of Vice-President Secrest.
11:00 A. M.—Reading of Papers in Zoology Section and in Joint Session of Geology and Physical Sciences Sections.
1:30 P. M.—Field Trip to Forest Arboretum on Grounds of The Ohio Agricultural Experiment Station under the leadership of Vice-President Secrest, Botany Section.

MINUTES OF BUSINESS MEETINGS.

The first business session was called to order by President Transeau at 9:50 A. M., on Friday, April 3, 1925, in the Auditorium of Taylor Hall. An adjourned session was held at the same place at 8:00 A. M. on the following day.

The President announced the appointment of the following committees for the meeting:

Committee on Membership—Geo. D. Hubbard, Chas. H. Otis, Clifford R. Cutright.

Committee on Resolutions—L. B. Walton, J. H. Schaffner, Carl Ver Steeg.

Committee on Necrology—F. O. Grover, John A. Bownocker.

The following *Auditing Committee* was elected by the Academy: Lynds Jones and S. R. Williams.

The following *Nominating Committee* was elected by the Academy by ballot: Raymond C. Osburn, J. Ernest Carman, E. L. Fullmer, Samuel W. Chase, F. C. Dockeray, L. W. Taylor.

Report of the Secretary.

The following report by the Secretary was received and ordered filed.

WOOSTER, O., April 3, 1925.

To the Ohio Academy of Science:

The duties of the Secretary were, as in past years, largely of a purely routine character. These were taken care of with the greatest possible dispatch. Among the transactions that seem to be of sufficient importance to warrant their review at this time may be mentioned the following:

Certificates of election to fellowship in the Academy were sent to all those thus honored at the Annual Meeting in 1924.

A brief report of the Thirty-fourth Annual Meeting of the Academy and a copy of the report of the Committee on Necrology were sent to *Science;* the former appeared in the issue of May 23, 1924, pages 470–472.

Information regarding the history and organization of the Ohio Academy of Science together with a copy of our Constitution and By-Laws was sent to applicants in two or three states where the organization of an academy was under consideration.

The following letter received by the Secretary speaks for itself:

TORONTO, SUNDAY, August 10, 1924.

DEAR MR. ALEXANDER:

I do not wish to let today pass without telling you how much I am enjoying my visit here and how heartily I appreacite having been sent by the Academy.

There are quite a number of Ohioans here, so one could not feel strange. But if there were none, the easy, informal way in which things are planned and carried out prevents any shyness or stiffness. To me the meetings seem better organized than our own just from that very standpoint—but this is merely a personal opinion.

Academy members who are here include R. C. Osburn, F. C. Blake, Alpheus Smith, A. P. Weiss, E. L. Rice and his father from Conn. Wesleyan, B. W. Wells, who is now in North Carolina but who still is a member of the Academy, Dr. Clare Martin of Bowling Green, and Albert Shadle. There may be others but I have not run into them.

The botanists' meetings have been splendid; a good many excursions are planned. I was much surprised when out of a clear sky my name was called to take part in the opening discussion on movement of food and water in plants. The president evidently remembered me from my visit to England in 1921.

Sincerely,

A. E. Waller.

In August, 1924, the Academy received a formal invitation to be represented at the inauguration of Robert Ernest Vinson, President of Western Reserve University, on October 9, 1924. Thereupon the Secretary wrote to Dr. Dayton C. Miller, Case School of Applied Science, Cleveland, asking him to serve as the duly accredited delegate of the Academy and he very kindly consented to do so. Doctor Miller's report follows:

Cleveland, O., Oct. 24, 1924.

Mr. W. H. Alexander, Secretary,
The Ohio Academy of Science, Columbus, Ohio.

My Dear Mr. Alexander:

In accordance with your appointment of October 1, 1924, I attended the inauguration of Robert E. Vinson as President of Western Reserve University on October 9, 1924. I registered officially as the Representative of *The Ohio Academy of Science* and signed the formal register of delegates. I attended the ceremony of inauguration and the banquet in this capacity, and expressed the greetings of *The Ohio Academy of Science* to the officials of the University.

I am enclosing a printed program of the exercises in which you will find *The Ohio Academy of Science* listed as participating in the occasion. I am sure the University appreciated the kindness and interest *The Ohio Academy of Science* took in this connection. With kindest regards, I am,

Yours very truly,

Dayton C. Miller.

The copy of the program sent by Doctor Miller is on file with the Secretary.

The Secretary was present to represent the Academy in the Council of the American Association for the Advancement of Science at the Washington, D. C., meeting. While there, the Secretary together with the Treasurer, participated in a conference of representatives from the various state academies called by Dr. Burton E. Livingston, Permanent Secretary of the A. A. A. S., for the purpose of going over and thrashing out the whole question of affiliation between the Association and the academies. We understand the Treasurer is prepared to give the Academy a complete digest of this whole matter together with a statement of the final action taken by Council of the A. A. A. S.

In December last, we received a letter from Mr. Ovid M. Butler, the Executive Secretary of The American Forestry Association, Washington, D. C., earnestly soliciting the endorsement of this Academy in an effort to secure through appropriate legislation National forest lands in

the Eastern half of the country. This matter is now presented to the Academy for its action.

In the last few days we have received a communication from one B. E. Skvirsky who, presumably, is speaking for the "Russian Information Bureau" in Washington, D. C., which, in turn, "is acting as representative of the Joint Information Bureau of Moscow in its endeavors to bring about closer contact between scientists as well as scientific and cultural organizations of the Soviet Union and the other countries." The communication was acknowledged and is now before the Academy.

Attention is also called to the fact that the Geology Section of this Academy held its annual field meeting and excursion in Cleveland and vicinity on May 30, 31 and June 1, 1924, under the leadership of Prof. J. E. Hyde of Western Reserve University. The committee composed of Vice-President Conrey, J. E. Carman and J. E. Hyde, prepared a most attractive program for this annual affair but we have no further report of same.

WILLIAM H. ALEXANDER, *Secretary.*

Report of the Treasurer for the Year 1924-1925.

The following report by the Treasurer was received and referred to the Auditing Committee whose report is appended:

To the Ohio Academy of Science:

The Treasurer submits the following report for the period from April 2, 1924, to March 13, 1925:

RECEIPTS.

Cash balance on hand	$ 554.73
Interest on certificate of deposit	39.00
Members dues paid through the A. A. A. S. and directly to the Treasurer	660.95
Total Receipts	$1,254.68

It is estimated that the library sales of publications will amount to $37.00, but a statement from Miss McKee is not available at this time.

DISBURSEMENTS.

To E. L. Rice, traveling expenses	$ 11.87
To Hotel Deshler, expenses for Dr. A. P. Mathews	12.00
To Wm. H. Alexander, honorarium	100.00
To A. E. Kraus	59.75
To B. E. Livingston	9.00
To B. E. Livingston	4.00
To A. E. Kraus	15.50
To A. E. Waller, traveling expenses to attend British Association meeting.	23.05
To Helen Coleman, stenographic assistance	7.34
To B. E. Livingston	7.00
To Wm. H. Alexander, secretarial expenses	23.16
To Delores Dehus, initial fee in A. A. A. S. remitted	5.00
To Esther Bearss, initial fee in A. A. A. S. remitted	5.00
To Schuler P. Hall, initial fee in A. A. A. S. remitted	5.00
To Helen Coleman, stenographic assistance	6.00
Total disbursements	$293.67
Cash balance on hand March 13, 1925	$961.01

CURRENT LIABILITIES (Estimated)

To the Ohio Journal of Science for each member's Journal subscription, approximately 320	$320.00
To honorarium for the Secretary, 1925	100.00
Printing and expenses of the 1925 meeting	100.00
Incidentals	40.00
Estimated total	$560.00
Estimated surplus for current year	$400.00

It is noted that the Academy will hereafter receive but half of the previous year's amount from the American Association. This will represent a loss of nearly one hundred dollars to the annual receipts. Since the Academy will send out its own statements there will be additional printing, postage and clerical assistance necessary.

It has been suggested that the Academy pay for a limited number of plates used in illustrating articles accepted by the editor for the Ohio Journal of Science. It has been expressed before in the Treasurer's reports that the Journal is the best place at our disposal for the expenditure of any small surplus the Academy may accumulate.

Respectfully submitted,

A. E. WALLER, *Treasurer.*

March 31, 1925.

Books, checks, vouchers submitted to the Auditing Committee and found to be correct.

LYNDS JONES,
S. R. WILLIAMS.

Report of the Executive Committee.

The following report of the Executive Committee was received and ordered filed:

WOOSTER, O., April 3, 1925.

To the Ohio Academy of Science:

A meeting of the Executive Committee was called by the President and was held at the Faculty Club Rooms, Ohio State University, Columbus, on December 20, 1924, with three members—Transeau, Waller and Alexander—present. Letters of regret were read from the other two members—Shatzer and Patten. President Transeau presided.

By unanimous vote it was decided to accept the invitation of the College of Wooster to hold the annual meeting for 1925 at Wooster, Ohio, and April 3 and 4 set for the meeting. The appointment of a local committee for the Wooster meeting was left to the President.

It was agreed that the preliminary announcements of the meeting should be issued not later than February 15 and that every effort should be made to obviate the conflict with the Educational Conferences held at the Ohio State University.

It was also agreed that in the event the Secretary was unable to attend the meetings of the A. A. A. S. at Washington, D. C., the latter

part of December, that the Treasurer, Dr. A. E. Waller, should be the representative of the Ohio Academy at a conference of representatives from the several state academies, called by Permanent Secretary Livingston, regarding the matter of affiliation.

It was further voted to recommend to the Academy the appointment of a permanent *Committee on Membership* at the Wooster meeting.

A second meeting of the committee was held last evening at Kenarden Lodge, College of Wooster, Wooster, Ohio, with three members present—Transeau, Waller and Alexander.

At this meeting twenty-seven applications for membership in the Academy were approved subject to final ratification by the Academy.

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary,*
For the Committee.

Report of the Publications Committee.

The following report of the Publications Committee was received and ordered filed:

WOOSTER, O., April 3, 1925.

To the Ohio Academy of Science:

The Annual Report of the Thirty-fourth Meeting, Proceedings, Vol. VII, Part 9, contained 39 pages and was published in September, 1924. The report minus the membership list was also published in the *Ohio Journal of Science: 24:* 209–229, 1924.

Respectfully submitted,

H. C. SAMPSON, *Chairman.*

Report of the Library Committee.

The following report of the Library Committee was not received in time to be presented to the Academy but is published for the information of the members:

COLUMBUS, O., April 8, 1925.

MY DEAR MR. ALEXANDER:

I regret very much that pressure of work kept me from submitting to the Ohio Academy of Science the report of the Library Committee in time for reading at the Wooster meeting. I am inclosing the report of Miss McKee of the University Library who has attended to the details of the work this year. I suppose it will be possible for you to include this material in the regular section of the minutes just as if it had been presented at the meeting itself.

MISS MCKEE'S REPORT.

The sale of publications for the year amounted to $40.36, $2.62 of which is still outstanding, $37.74 having been turned over to the Treasurer of the Academy.

Late in December the Proceedings of the Thirty-fourth Annual Meeting were received from the printer and were mailed out in January to the members of the Academy and the exchange list.

Exchange publications received by the Academy have been filed in the Library, some additions having been made to the list this year and one or two that were interrupted by the European war have been revived recently.

ALICE D. MCKEE.

Respectfully submitted,

C. W. REEDER, *Chairman.*

Report of the Trustees of the Research Fund.

The following report of the Trustees of the Research Fund was received and ordered filed:

COLUMBUS, O., April 1, 1925.

To the Ohio Academy of Science:

The accounts of the research fund which came into our hands at the close of the last meeting, proved upon reference to the bank deposits, to amount to the sum of $1,324.82 as indicated in the Proceedings of the last annual meeting. $1,300.00 of this amount was put into 7% bonds, leaving a cash balance of $24.82. The addition of interest in November increased this to $1,362.91. Accrued interest due May 1st, will bring this amount to $1,407.41. There have been no bills submitted or paid which is in accordance with the instruction of the Academy, that the funds be conserved during the year and that the trustees recommend a plan of use for the fund in the future.

The question of how to best utilize the research fund, is a somewhat difficult one, but the trustees would suggest the following as a plan which may be subject to modification if the developments of the future indicate a better method.

We recommend that the income from $1,000.00 of the research fund be available each year for a grant to be known as the McMillin grant and which may be used either for the assistance in some research problem or given as an award in recognition of some especially noteworthy contribution of some member of the Academy. That the balance of the fund and income derived from it, shall be used or allowed to accumulate as the trustees may deem best in any particular year, it being understood that the fund or any interest income shall in all cases be used for the encouragement of research either by grants for individual problems or for the publication of papers resulting from research.

Respectfully submitted,

EDWARD L. RICE,
GEO. D. HUBBARD,
HERBERT OSBORN, *Chairman.*

Report of the Committee on State Parks and Conservation.

The following report of the Committee on State Parks and Conservation was received and ordered filed:

WOOSTER, O., April 1, 1925.

To the Ohio Academy of Science:

It was impracticable to have a meeting of the full committee, but the chairman has requested members of the committee to send him suggestions or remarks concerning the possibilities of work in the committee and has had replies from several members with varied suggestions. It is hoped that the committee may have a meeting in the future and formulate some definite suggestions concerning the management of the State Forest Areas, the Forest Parks and the Game Refuges, which are now under control of state authorities, and we believe that these areas offer a very practical means of preserving the State fauna and flora, and that with the cordial support of the authorities in charge of them, it would be possible to adopt measures which will furnish the most desirable conditions for the use of the parks as well as for the preservation of the native fauna and flora.

The most recent advancement has been the acquisition of a number of tracts for state forests and I cannot do better than quote a statement from Professor Secrest, the State Forester, and a member of this committee, concerning the progress in this line:

"The state department of Forestry was given authority by statute in 1916, to acquire lands for state forest purposes. The price of such land cannot exceed $10.00 per acre. In 1923 the state forest law was amended, permitting the Department to acquire 'areas of outstanding scenic value, virgin woodlands, and lands containing unusual flora.' In the purchase of such tracts the price is not limited by statute.

"From 1916 to 1921 it was difficult to secure funds for acquiring state forests. Increased appropriations from the Legislature were secured in 1921, and in 1923 were doubled, being $100,000 for the biennium.

"To date six state forests have been acquired totaling approximately 14,420 acres. These tracts comprise the Dean State Forest of 1,500 acres in Lawrence County; Waterloo State Forest, of 221 acres in Athens County; Scioto County State Forest, 5,200 acres, in Scioto County; Scioto Trail State Forest, of 5,900 acres in Ross County; Pike County State Forest, 1,100 acres in Pike County; and Mt. Logan State Forest of 500 acres in Ross County (under lease from Federal Government.)

"The state forests are located for the most part on 'absolute forest land,' and the tracts are to be devoted not only to experiments and demonstrations in timber culture, but to park and recreation uses as well. The present areas are in some cases nuclei to be further extended in the future. This is particularly true of Dean, Pike, and Scioto Forests. Land can be purchased within the limit of $10.00 per acre. The topography is rough, the soils thin, and the land largely stocked with second growth hardwood and pine forest. The open area is under 10%, and is in

most cases the typical abandoned fields, which when cultivation ceases are quick to revert to the typical Appalachian Plateau temporary forest types. About 300 acres of these old fields on the State Forests have been planted to a considerable variety of forest trees, which give promise for reforestation purposes. The forestry problems are largely those of protection against fires, and the management of the native forest stands. The State Forests are a delightful place for visitors who are interested in all forms of wild life, and the existing flora and fauna will be preserved and replenished by the protection now afforded these areas.

"The first forest parks were purchased in 1924. Logically enough the start was made in Hocking County where doubtless all will agree by and large Ohio's most outstanding, and interesting scenic areas exist. This is known as the 'cave region.' Not only is the geology most interesting, but the flora is decidedly varied, unique, and interesting. The gorges contain immense specimens of the original virgin woodland—hemlocks, tulip trees, oaks, maples, three species of birch, and a wealth of wild flowers.

"The well known Rock House, The Gulf or Old Man's Cave, and Kunkle's Hollow are now in possession of the State. An option has been secured on Ash Cave, and it can soon be taken over. Other interesting places in this region are contemplated for purchase.

"Other forest parks are under consideration in different parts of Ohio.

"The Parks will be open to the public under rules and regulations free of charge and arrangements will be made to provide accessibility and comfort to a degree that will satisfy those who love the outdoors, and nature's handiwork. The old fields in connection with the Parks, will be planted to trees so that the greatest usefulness will obtain.

"The State Forests and Forest Parks either purchased or under option now number 12, and total approximately 16,500 acres. The number and total area will be increased by July 1st with funds now available."

Professor Fullmer reports that there have been additions to the Cleveland Metropolitan Park System, which now consists of some 4,500 acres, and that "this is being added to from time to time and the opening of roads into some of the tracts has made them more available. It is planned to make a lake of some 100 acres on this portion of the tract near Whips's ledge. This tract lying about 15 miles south of the city in Medina County, has been enlarged by a gift since we visited it two years ago."

Professor Shatzer states that there is opportunity for the development of several miles of River Area Park in the vicinity of Springfield and that it is hoped this tract may be utilized.

The additions to the game refuges which are under the supervision of the Fish and Game Commission have not been reported recently, but while these do not give as permanent a guarantee of preservation as the State forests, they undoubtedly will serve a very valuable purpose, and the refuges which are permanent State property are being so administered that we believe they will prove of much value as biological centers.

The chairman of this committee visited the Royal Palm State Park of Florida last week and was much interested in learning as to its management. It is managed by the State Federation of Women's Clubs under authority of the State and maintains a lodge and provides picnic grounds for tourists, but with scrupulous care to preserve the natural conditions of a very unusual tract of biologic interest.

Respectfully submitted,

HERBERT OSBORN, *Chairman.*

Report of the Committee on Legislation.

WOOSTER, O., April 3, 1925.

To the Ohio Academy of Science:

Unfortunately the members of this committee are rather widely scattered over the State and it has been, therefore, practically impossible to get a quorum present for a formal meeting. A meeting was called for January 10, 1925, but a quorum did not appear. Thereupon the chairman of the committee called together a number of the members of the Academy living in Columbus and vicinity. At this conference were President Transeau, Professors Herbert Osborn, F. H. Krecker, and C. W. Reeder, and the chairman.

The only matter considered at this informal meeting was whether or not an attempt should be made to get a bill through the 86th General Assembly, and if so, in what form. It was agreed that we should make the effort and the following draft was worked out and submitted to the members of the committee:

H. B. No. 123.

A BILL

RELATIVE TO STATE RECOGNITION OF THE OHIO ACADEMY OF SCIENCE.

Be it enacted by the General Assembly of the State of Ohio:

SECTION 1. The Ohio Academy of Science, a corporation not for profit, incorporated under the laws of Ohio, March 12, 1892, shall be under the control of a board of trustees consisting of fifteen members to serve without salary or per diem. Six of the members of the board shall be appointed by the governor with the advice and consent of the Senate, two to serve for two years, two to serve for four years and two to serve for six years, and until their successors are appointed and qualified, and thereafter two members shall be appointed every two years to serve for a term of six years. The remaining nine members of the board shall be elected by the members of the Academy.

SEC. 2. On and after the taking effect of this act, the Ohio Academy of Science shall constitute an official source of advice and information on all scientific questions within its field submitted to it by any state department or officer thereof. The services of the Academy shall be available to the state or any of its officers in any matter within its field in which the consideration of scientific facts or policies may be involved, and the officers of the state may call upon the Academy of Science, through its properly elected officers or committees appointed by its officers, for such consultation and advice as may be of service to them in their duties. The members of such committees shall receive no compensation for their services, except that all traveling, clerical and other necessary expenses shall be paid. No member of the Ohio Academy of Science, while serving on any such committee, shall be eligible for expert service under advice from said committee for which compensation from the state is received.

SEC. 3. The Ohio Academy of Science may issue from time to time publications dealing with the results of scientific investigations. Through such agency or agencies as the board ot trustees may designate, said publications shall be made available by distribution, exchange, or sale, to the citizens of Ohio, scientific workers and scientific societies.

SEC. 4. The board of trustees shall submit biennially, to the director of finance, a budget covering the necessary expenses to be incurred in carrying out the provisions of this act, and the general assembly shall make such appropriations as it may deem advisable.

It was further agreed that in as much as Mr. E. J. Riggs of Gallia County introduced a similar bill at our request in the 85th Assembly (H. B. No. 400) he be asked to introduce the bill in the 86th Assembly. This he very kindly consented to do and the bill was introduced as drafted and became known as H. B. No. 123. It was referred to the Finance Committee and after considerable delay the committee gave us a hearing on the Bill. At this hearing appeared on behalf of the Academy, President Transeau, Mr. Arthur Harper, Mr. E. S. Thomas, Dr. R. C. Osburn and the Secretary. The hearing was respectful but purely perfunctory, as it was clearly evident that the Finance Committee had already closed the door against the Bill. The adverse decision of the committee announced a few days later was not a surprise.

The committee is of the opinion that if the Academy is to continue its efforts along this line—and it so recommends—and hopes to get results, it will be necessary for the Academy to resolve itself into a "committee of the whole" and make a united effort to interest the members of the Assembly through the "folks at home."

W. H. ALEXANDER *Chairman*,
EDWARD L. RICE,
L. B. WALTON.

Election of Officers and Committeemen.

The following officers and committeemen were duly elected by vote of the Academy upon the recommendation of the Nominating Committee:

President—Paul M. Rea, Cleveland Museum of Natural History, Cleveland.

Vice-Presidents:

Zoology—Clarence H. Kennedy, Ohio State University, Columbus.
Botany—W. Garfield Stover, Ohio State University, Columbus.
Geology—W. H. Shideler, Miami University, Oxford.
Psychology—Harold E. Burtt, Ohio State University, Columbus.
Medical Sciences—Dr. Samuel W. Chase, Cleveland.
Physical Sciences—Robert C. Gowdy, University of Cincinnati, Cincinnati.

Secretary—William H. Alexander, U. S. Weather Bureau, Columbus.
Treasurer—A. E. Waller, Ohio State University, Columbus.
Elective Members of Executive Committee—Lewis G. Westgate, Delaware; and M. E. Stickney, Granville.

Publication Committee—Henry C. Beardslee, Perry.
Trustee Research Fund—Geo. D. Hubbard, Oberlin.
Member Library Committee—E. L. Moseley, Bowling Green.
Committee on Legislation—Wm. H. Alexander, Columbus; M. M. Metcalf, Baltimore, Md.; Paul M. Rea, Cleveland; Edw. L. Rice, Delaware; L. B. Walton, Gambier.
Representatives on the Editorial Board of Ohio Journal of Science:
Zoology—R. A. Budington, Oberlin College, Oberlin.
Botany—Bruce Fink, Miami University, Oxford.
Geology—Wilber E. Stout, Ohio State University, Columbus.
Psychology—Erwin A. Esper, Ohio State University, Columbus.
Medical Sciences—F. C. Waite, Western Reserve University, Cleveland.
Physical Sciences—(Vacant).

Election of Members.

The following persons were regularly nominated and elected to membership in the Academy:

Blaydes, Glenn W.; Botany; 95 Oak Hill Ave., Delaware.
Bognar, E. J.; Geology; 1125 S. Seneca, Alliance.
Brown, Walter B.; Zoology, Anatomy, Physiology; Granville.
Bushnell, John; Botany; Ohio Agr. Exp. Station, Wooster.
Campbell, Robert J.; Botany, Entomology; O. S. U., Columbus.
Chase, John H.; Geology, Biology; 69 Benita Ave., Youngstown.
Cherry, Helen; Bacteriology, Geology; R. F. D. 1, Bellwood, Pa.
Clarke, Leota B.; Chemistry; 3103 12th St. N. W., Canton.
Copp, Paul T.; Mathematics; 233 Hartshorn St., Alliance.
Cutright, Clifford R.; Zoology, Entomology; Ohio Agr. Exp. Sta., Wooster.
Dike, Clyde E.; Botany; Ohio Agr. Exp. Sta., Wooster.
Diller, Jesse D.; Botany; 1501 Neil Ave., Columbus.
Dunn, Paul H.; Geology; Miami University, Oxford.
Frye, Walter; Geology; 209 Grand Ave., Akron.
Grady, Roy I.; Physical Sciences; 722 N. Bever St., Wooster.
Hay, Lloyd Q.; Biology, Physiology; North Industry.
Hersh, A. H.; Zoology; Adelbert College, W. R. U., Cleveland.
Howe, C. E.; Physical Sciences; 189 E. College St., Oberlin.
Howlett, Freeman S.; Horticulture; Ohio Agr. Exp. Sta.; Wooster.
Kuegle, Paul C.; Geology; R. F. D. 4, Loveland Road, Youngstown.
Lord, Richard C.; Physical Sciences (Chemistry); Gambier.
Miley, Hugh H.; Zoology; Miami University; Oxford.
Morgan, Mary S.; Forestry, Psychology; Astronomy; Girrard.
Nelsen, Olin E.; Microscopic Anatomy, Physiology; 335 Field Avenue, Toledo.
Palmer, Mary C.; Biology, Nature Study; R. F. D. 2, 760 Midlothian Road, Youngstown.
Poos, F. W.; Entomology; Box 283; Sandusky.
Price, John W.; Zoology; Pataskala.

ROTH, CONRAD; Birds, Wild Flowers, Forestry; 1715 Robinson Ave., Portsmouth.
ROWLES, EMMETT; Zoology, Medical Sciences; 97 Franklin Ave., Athens.
SCOTT, JOSEPH M.; Bacteriology, Animal Parasitology; 141 Simpson St., Alliance.
SCOTT, LUTHER C.; Geology; Toledo University, Toledo.
SPENCER, WARREN P.; Zoology; 138 N. Walnut; Wooster.
STEELE, MIDA L.; Botany; R. F. D., 1, Creston.
STEWART, GRACE A.; Geology; O. S. U., Columbus.
STINCHCOMB, G. A.; Physical Sciences; 138 Greenfield St., Tiffin.
SWENSON, ENGELBREKT A.; Physiology, Anatomy; W. R. U., Cleveland
TAYLOR, L. W.; Physical Sciences; 30 N. Pleasant St.; Oberlin.
TERWILLIGER, CHAS. VAN ORDEN; Physical Sciences; O. S. U., Columbus.
THIESSEN, NORMA W.; Chemistry, Biology; 1491 Lakeland Ave., Lakewood.
THOMPSON, OSCAR E.; Zoology, Botany; 42 Rice St., Alliance.
TRIESCHMANN, JACOB E.; Physical Sciences (Chemistry); 28 W. Davis St., Tiffin.
WATSON, S. A.; Biology; Wilmington College, Wilmington.
WESTHAFER, W. R.; ————; College of Wooster, Wooster.
WIEBE, ABRAHAM H.; Biology; Bluffton.
WILCOX, R. B.; Botany; Wooster.
WILLIAMS, C. G.; Physical Sciences; Ohio Agr. Exp. Station, Wooster.

Report of the Committee on the Election of Fellows.

WOOSTER, O., April 3, 1925.

To the Ohio Academy of Science:

A meeting of the Committee on the Election of Fellows was held last evening at Kenarden Lodge, College of Wooster, Wooster, Ohio. Six members of the committee were present and the other members were represented by proxy.

Of the candidates considered, two received the necessary nine favorable votes and were declared elected. The fellows elected will be personally notified, and the list will be published in the Proceedings of this meeting.

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary,*
For the Committee.

The following is a list of those elected Fellows:

HENRY CURTIS BEARDSLEE
JOSEPH H. TODD

The following Special Report on the Relations between the American Association for the Advancement of Science and The Ohio Academy of Science was received and ordered filed:

WOOSTER, O., April 2, 1925.

To the Ohio Academy of Science:

The plans for affiliation between the American Association and the various state academies were made the subject of action at the St. Louis meeting of the Association in 1919. In January of 1920 your Treasurer was asked to inquire of Doctor L. O. Howard the results of this action and received the following reply:

"Yours of the 6th has come. I find that your understanding of the affiliation matter is correct and corresponds with the action of the Council at St. Louis, with the exception of No. 1. Following is a transcript from the minutes of the Council meeting of December 29th:

"The Committee on Affiliation of State and Local Academies reported the following recommendations:

"1. That State academies be affiliated on a financial basis that will yield the Association four dollars net per member.

"2. Any State academy which concludes arrangements for affiliation within the first six months of 1920 may be accepted for the entire year 1920, fees paid to the Association before that date to be adjusted in accordance with the detailed plan.

"3. Two alternative plans are considered with respect to membership in the academies, namely (a) All members of the academy to affiliate with the Association; (b) To establish two grades of membership, of which one will be national, involving membership in both academy and Association; the other local, consisting of academy membership only.

"4. The academies will collect joint dues and transmit the Association's share to the Treasurer.

"Voted that the report of the Committee on Affiliation of State and Local Academies be received and approved.

"Your No. 4 is all right. The collection of four dollars instead of three by the Association is necessitated by the new arrangement by which the Association pays the journal *Science* three dollars for each new member. You see we must have something for overhead expense."

It is clear from this letter that our Academy was not altering its dues, but that the Association was to receive one dollar less for the subscription to "Science" from all of its affiliated State Academy members. That this is plainly understood as the basis of the financial arrangement is still further brought out in a letter dated May 21 from Dr. B. E. Livingston, who succeeded Dr. Howard as Permanent Secretary of the Association:

"Replying to your several letters, your ideas about the nature of the affiliation between the Ohio Academy of Science and the American Association for the Advancement of Science are quite right. I think I have everything clear now.

We refund \$1 for each member of the Academy who has paid \$5 dues to the American Association for 1920. For each new member you are to send this office \$4, together with his name and address and a statement of which journal he prefers. The journal will be ordered as soon as the remittance and data are at hand. Since back issues of the journals are limited, prompt action is necessary. Also, of course a new member would like to have his journal begin promptly. I suggest that you send me new members' names and remittance for them so that they will reach here on Wednesday of each week. We send our list to Science every Friday.

"I want to ask you if you can follow this scheme for collecting dues next October. We will have a special statement card prepared for Academies. On its front will be a statement of the affiliation and blank spaces for imprinting the Academy name and the bill for 1921 dues. On the back will be blanks to be filled in by members, for information for this office and for Membership List, A. A. A. S. We will put the name and address of member on front of card and send all cards to you. We will also supply window envelopes for you to mail cards out in. You are to send these out about September 25 or so and they are to come back to you, with members' remittances. You are to send the cards to this office with $4 for each one. This scheme will get your members on cards here which are just like the cards of our other members. I hope you will fall into this idea, for it is essential that we have the same system for all our members. A new membership list is being prepared and it is necessary that we have all the information about all members promptly after October 1."

It was not only clear from this that the Association was expecting to reduce the joint dues of members of both organizations, but also they were going to help in obtaining an increasing membership in the Academies.

After a year of this, however, the cost to the Association of remitting one dollar to each of its members who was also a member of a state Academy was greater than at first anticipated. In the correspondence of that period with Dr. Livingston, this amount lost to the Association by its voluntary relinquishment of one dollar of the price of the subscription to "Science" came to be regarded as money needlessly turned back to the individuals from whom it had been collected. From the point of view of State Academies which do not publish Journals or Proceedings of a scientific nature and whose membership fee had always been lower than ours in the Ohio Academy it was a clear gain of a dollar per member. Dr. Livingston wishing to call attention to what was undoubtedly great financial assistance to these Academies gave a name to the remitted funds and called them "*Grants of the Association to the Academies*." It must be remembered however that in our Academy we had not changed our dues or our Journal costs. To us it was simply the arrangement originally proposed in the St. Louis meeting of the Association, namely—a reduction in the cost of *Science*. We did not see any reason for charging more for the *Ohio Journal of Science* for the members of the Association than for the Academy members who were not also Association members, and we simply returned the money to the former. Personally speaking I did not think that a mistake at the beginning of our affiliation and I do not think it a mistake now.

Correspondence was often voluminous over the manner of payments of the members and the affiliation arrangement for the past five years has been purely a financial arrangement from which no scientific benefits have accrued. As there were new plans evolved they would often come as "instructions" from the Association office. There was no way of obtaining a list from the Association of its members who were desirable from the standpoint of their attainments and residence in the State as prospective members of the Academy. We furnished the Association each year with the lists of our members. In 1923 the increases in enrollment in the Association through direct recommendation of the Treasurer were counted as seventeen. No account was taken at that time of the

total increases in Ohio. This was putting the increases in membership in an unfair light as undoubtedly the Academy members many of whom are science teachers and research students were largely responsible for these new memberships in the Association.

The Association after two years of having dues collected by the Treasurer in each of the affiliated Academies decided to collect its own dues. This seemed to your Treasurer psychologically unsound, as it meant that two bills in place of one must be collected from each member. The following paragraph is taken from a letter to Dr. Livingston written by the Treasurer under date of March 8, 1923:

> "Your letter of February 23d which should have been sent to me was forwarded by Dr. Rice and reached me yesterday. You are doing the Ohio Academy of Science a great injustice in supposing that only seventeen new members were received through the Academy for the A. A. A. S. Our lists are not worth checking over on this point, but I know more than seventeen members have been added. You are doing the Academy a serious injury in changing the billing of the A. A. A. S. members from the office here to the Washington office because the members have just been trained to send the money here. Now your order (for that strong word is just about what it amounts to) comes, to abandon this system and substitute the collection directly through your office. Certainly the Academy can not be supposed to have been glad to collect the money for you in the first place. They did it simply as an accommodation and in the matter of the affiliation it seemed as though it would be an easy way of completing the arrangement."

With all of this there was still nothing but a financial arrangement and there was no scientific advance. There was further an annoying distinction made between the affiliated academies and the affiliated Societies which was also on a financial basis, namely that a five dollar initial fee was remitted if the new member was also a member of an affiliated Society. It was in consequnece difficult to find out exactly what a new member should pay.

Passing over the correspondence of the next year, we wish to note the work of Professor Osborn in attempting to raise the level of the basis of affiliation from an exchange of checks to the point where scientific work might be benefited. A paragraph from a letter of Dr. Transeau to Dr. Livingston under date of December 8, 1924, will serve:

> "In view of the difficulties attending the collection and distribution of the dues, and the apparent change in point of view of the American Association indicated by a comparison of your letter with that of Dr. Howard, I would suggest that the proposal made by Professor Herbert Osborn might meet the situation. As I understand his scheme, it is that the dues be collected as before the affiliation, and that the Association actually subsidize the academies according to their membership, $25 for those having one hundred members or less, $50 for those having between one and two hundred members, and $100 for those having 300 or more members. These amounts would be credited to the Academy as a whole and would not be rebated to members. In this way the affiliation would not be weakened and the Association would not be called upon for any large contribution to the Academies."

This letter was written shortly before the Washington meeting of the Association. Through the Association's committee on State Academies and the letters from the affiliated academies registering protests to the secretary there was at the last meeting an attempt to come to an understanding and to bring our affiliation to a reasonable arrangement,

namely, to cost the Association less, but to derive more of scientific benefits from the work of the scientific men of the country. The Association has spent more money than it feels it should by reducing the price of *Science* to Academy members and is proposing a new and less expensive arrangement. It is contained in the following paragraphs:

(10) The Council adopted the following resolutions concerning the future of arrangements with affiliated academies of science and local branches:

(a) In view of the rapid increase in the number of members concerned, it has become impossible to continue the annual grants to affiliated academies and local branches as in the past, and the association consequently finds it necessary to reduce the allowances for these organizations, for 1926 and until further notice, to one-half of the present amount per member. This reduction is to go into effect October 1, 1925.

(b) All members of any affiliated academy are to be at all times, until further notice, eligible to admission to the association on certification by the proper academy officer and without payment of the usual entrance fee.

(c) The permanent secretary is instructed to take up the applications for academy affiliations according to the modified arrangements for academy affiliation now authorized.

5. Since the academy allowance from the Association is now to be but 50 cents per year per member, it seems desirable that the affiliated academies should collect full academy dues from their association members. It is hoped that those academies that have heretofore credited association allowances as academy dues will arrange this matter this spring, so that there may be no misunderstanding on the part of their members next fall when the new rule is to go into effect. It may be desirable for the proper academy officer to send to all association members of his academy an announcement on this subject, either before or at the time of sending out the bills for annual dues. The facilities of the permanent secretary's office are offered to the affiliated academies in this and similar kinds of circularization; multigraphing, mimeographing or printing circulars or letters and the addressing of envelopes for academy work can be cared for at the Washington office at actual cost or less, if the academy so desires. The general facilities of the office are to be at the service of the affiliated academies, with probably some saving in cost.

Since the arrangement between the American Association and the Academy has been largely a financial one, your Treasurer has cared for most of the correspondence. The Association promises for the future that the affiliation will have less of a financial and more of a scientific conscience. The association therefore asks the appointment of a representative from each of the State Academies. This is expressed in the recent communication under date of March 21, 1925, as follows:

REPRESENTATION OF AFFILIATED ACADEMIES IN THE ASSOCIATION.

D. Each affiliated academy is to have, as heretofore, a representative in the council of the Association, thus taking part in the direction of association affairs.

It is hoped that the academy representatives will be named as early in the year as possible, so as to be listed in the permanent secretary's files. If an academy representative is to be unable to attend an annual meeting of the Association another may at any time be named to take his place. In general, an academy representative will be considered as remaining in office until his successor is officially named to the permanent secretary's office.

It is suggested to the Ohio Academy that this representative be appointed as heretofore by the executive committee.

It cannot be denied that the Association has maintained a vacillating policy toward the State Academies. That this probably will continue is to be seen in the following paragraphs from the communications of March 21 from Dr. Livingston (italics inserted by the Treasurer).

G. *Term of these arrangements.*

"It is understood that those arrangements of academy affiliation are not to be considered as in any way binding on the Association beyond the actual statements here made. The arrangements here described are to go into effect October 1, 1925, *and are to be continued until further action by the council of the Association.* Modifications may be made from year to year and the nature of such modifications will doubtless be determined by the degree of success with which the purposes of the affiliation are fulfilled. It is understood, however, that no changes in the financial or membership aspect of these arrangements will be placed in operation without at least a six-months' preliminary notice to the academies. An academy may withdraw from the affiliation on six months' notice.

"*It is to be hoped that the affiliated academies will continue to increase in strength and that the time may soon come when they will not need to accept financial grants from the Association.* It is to be remembered that the source of academy allowances is solely the association membership dues paid by members and that there are before the Association many projects for advancing American science that will require funds from this source. If any affiliated academy may find it possible to remit its annual association grant such action will be greatly appreciated by the latter, the funds thus freed will be utilized to advance science in other ways, and the non-financial aspects of the affiliation may be strengthened by such remission of grants.

"The officers and representatives of the affiliated academies are invited to make further suggestions for improving the association-academy relations, and to inform the permanent secretary as to their approval or disapproval of the paragraphs of this memorandum, or as to their suggestions regarding the improvement."

A. E. Waller, *Treasurer.*

April 2, 1925.

Following the reading of the above report, there was considerable discussion, pro et con, relative to the advisability of continuing the affiliation between the Ohio Academy of Science and the A. A. A. S. Finally, upon motion of L. B. Walton, seconded by R. V. Bangham, the matter was referred to the Executive Committee with power.

Report of the Committee on Resolutions.

The following resolutions were submitted by the Committee and unanimously adopted by the Academy:

1. The Ohio Academy of Science wishes to express its appreciation to *The College of Wooster*, The Ohio Agricultural Experiment Station and the unusually efficient local Committee, for making this, the Thirty-fifth Annual Meeting one of the most successful as well as enjoyable the Academy has held.

2. The Academy furthermore desires to extend to the representatives of the Press its cordial appreciation of the space given in the papers to the program and to the results accomplished by the members of this Academy.

3. The Ohio Academy of Science in session at Wooster, Ohio, wishes to place itself on record as deploring the recent action of the Governor and the Legislature of the State of Tennessee in connection with their recent enactments relative to natural phenomena. The publicity thus developed will prove disadvantageous to the best interests of the State.

4. The Ohio Academy of Science assembled at Wooster, Ohio, wishes to express its sympathy to the teachers of science in Tennessee in connection with the handicaps under which they have been placed in teaching the truths of nature.

L. B. Walton,
J. H. Schaffner,
Carl Ver Steeg,
Committee.

Report of the Committee on Necrology.

The Committee on Necrology records the loss by death during the year of four members, *viz.*:

Charles W. Napper, Greenfield;
Prof. A. D. Selby, Ohio Agricultural College, Wooster;
Prof. Septimus Sisson, Ohio State University, Columbus;
Prof. Herrick E. Wilson, Oberlin College, Oberlin.

Scientific Sessions.

The following is the complete scientific program of the meeting:

PRESIDENTIAL ADDRESS.

Accumulation of energy by plants.........................Edgar N. Transeau

PUBLIC LECTURE

The work of the Ohio Agricultural Experiment Station.........C. G. Williams

PAPERS

1. Orchard Spraying and Human Health. (10 min.)..............J. S. Houser
2. Local Lists of Plants and Animals. (20 min.).................Lynds Jones
3. Modern Ideas of Soil Development. (20 min.)...............G. W. Conrey
4. Entomological Conditions in Cuba. (20 min.)..............Herbert Osborn
5. A Biological Basis of Learning. (20 min.)..................H. M. Johnson

6. Daily Life of the American Eagle; Early Phase (30 min.) (lantern)........ FRANCIS H. HERRICK
7. Relation of Temperature and Rainfall to Hessian Fly Development. (15 min.) (lantern)..H. A. GOSSARD
8. Seiches in Lake Erie and Their Ecological Significance. (20 min.) (lantern).......................................FREDERICK H. KRECKER
9. Repeated Rejuvenations in Hemp. (12 min.).............JOHN H. SCHAFFNER
10. The Dynamic Factor in Heredity. (12 min.)................A. B. PLOWMAN
11. Monocular and Binocular Vision. (15 min.)................PRENTICE REEVES
12. A Theory of Nerve Conduction and Its Application to Imagination and Habit. (15 min.)..N. M. JOHNSON
13. Intra-relationships of Echinoderms as Evidenced by Ciliation. (10 min.) (lantern)...R. A. BUDINGTON
14. The Relation of the Respiratory Exchange to Differentiation and Dedifferentiation in Obelia Sp. (10 min.).......................EMMETT ROWLES
15. The Sexual Structures of Polydesmus Serratus. (10 min.).STEPHEN R. WILLIAMS
16. The Development of the Male Gonopods in Euryurus Erythropygus, Brandt; a Polydesmid Millipede. (10 min.)...............HUGH H. MILEY
17. On the Structure of a Trematode of the Genus Eumegaceste Found in the Cloaca of the Common Tern at Put-in-Bay in 1924. (10 min.)........ JOSEPH N. MILLER
(Introduced by Prof. F. H. Krecker)
18. The Correlation of the Seasonal History of the European Corn Borer with Seasonal Planting of Corn. (5 min.) (lantern)................L. L. HUBER
19. Aphids New to Ohio. (By title)...........................C. C. CUTRIGHT
20. Some Reactions of Pemphigus Sp. (5 min.) (lantern)........C. C. CUTRIGHT
21. Exact Determination of Food Requirements in Bringing Insects to Maturity. (10 min.)..E. R. BRYANT
22. On the Anatomy of the Head and Thorax in Ranatra (Heteroptera). (10 min.) (lantern)..C. R. NEISWANDER
23. The Evolution of Insects Based on a Study of the Appendages. (10 min.) L. B. WALTON
24. A Biological Record and Classification Card. (5 min.)........L. B. WALTON
25. The Calorigenic Effect of Adrenalin. (15 min.).................M. W. CASKEY
26. Some Observations on the Architecture of the Spongiosa of the Calcaneus. (15 min.) (lantern) (See demonstration No. 1)..........SAMUEL W. CHASE
27. Rickets and Osteoporosis in Swine as Affected by Nutrition. Dietary Factors. (15 min.) (lantern)...............................G. BOHSTEDT
28. Rickets and Osteoporosis in Swine as Affected by Nutrition. Pathology. (15 min.) (lantern)...................................B. H. EDGINGTON
29. The Effect of Light on Calcification of Bone. (15 min.) (lantern)...... R. M. BETHKE
30. Some Preliminary Notes on the Plankton of the Kartabo Region, British Guiana. (10 min.) (lantern)..............................HUGH M. RAUP
31. Some Factors Which Determine the Size of the Eye of Drosophila. (15 min.)..A. H. HERSH
32. A Note on Wing Venation in Certain Diptera. (5 min.) (lantern) JAMES S. HINE
33. Experiences and Experiments in Teaching Embryology. (10 min.)...... BRADLEY M. PATTEN
34. The Fauna of a Limestone Spring in Cliff Park, Springfield, Ohio. (10 min.) (lantern)..HUGH M. RAUP
35. The Relative Values of Morphological Adaptations. (10 min.).......... CLARENCE H. KENNEDY
36. Relation of Temperature to the Physiology of the Potato Plant. (15 min.) JOHN BUSHNELL
37. Some Abnormalities in Mnium. (10 min.)...................CHAS. H. OTIS
38. Certain Aspects of the Chemical Composition of the Apple Flower. (12 min.)..FREEMAN S. HOWLETT
39. Lodging in Oats and Wheat. (15 min.).......................F. A. WELTON
40. Variations in American Crab Apple (Malus Glaucescens, Rehder). (5 min.)...E. L. FULLMER

41. Some Factors Influencing the Development of Venturia Inequalis. (10 min.)....................H. C. Young
42. Degeneration of Potatoes in Ohio. (15 min.) (lantern)......Paul E. Tilford
43. Effects of Lightning on the Trunk of Platenus Occidentalis. (5 min.).... John H. Schaffner
44. The Microchemistry of Flax Fiber Formation. (10 min.) (lantern)...... Donald B. Anderson
45. Some Fresh Water Algae from Fukien, China. (5 min.).....L. H. Tiffany
46. Pre-Staining in Histological Technique. (10 min.)............Chas. H. Otis
47. The Seasonal Development of Apple Scab in Central Ohio in 1924. (10 min.) (lantern)....................H. W. Johnson
48. The Genus Oedogonium. (15 min.)........................L. H. Tiffany
49. Experiments on the Control of Apple Scab in Central Ohio in 1924. (10 min. (lantern).....................W. G. Stover and H. W. Johnson
50. Some Mississippian Physiography of Northeastern Ohio. (25 min.)..... G. F. Lamb
51. Peneplains and Straths in Southern Ohio. (15 min.)..........Wilbur Stout
52. Peneplains in Muskingum County, Ohio. (10 min.)...........G. W. Conrey
53. The Uplands of Jefferson County, Ohio. (5 min.)...........R. E. Lamborn
54. A Method of Estimating Post-Glacial Time. (10 min.) (lantern)...... Allyn C. Swinnerton
55. Geologic Structures in Southern Vermont. (15 min.).....Geo. D. Hubbard
56. Limestone Caves in Ohio (10 min.)........................Geo. W. White
57. The Areas of Distribution of Paleozoic Seas in the Arctic Regions of North America, Europe and Asia, in Connection with the Problem of Circumpolar Seas. (15 min.)............................Aug. F. Foerste
58. Difference in Niagaran Faunas Due to Development in Distinct Arms of the Sea, in Connection with the Cincinnati, Kankakee, LaSalle and Other Anticlines. (15 min.)..............................Aug. F. Foerste
59. A Drag Fault. (8 min.)..G. F. Lamb
60. Some Recent Deep Wells in Ohio. (15 min.)...............J. A. Bownocker
61. Dip and Expansion of Deep-seated Rocks in Eastern Ohio. (10 min.).... Wilbur Stout
62. The Members of the Monroe and their Distribution in Ohio. (15 min.)... J. Ernest Carman
63. Some Striking Features of the Lower Mercer Limestone in Mahoning County (8 min.) (Introduced by Prof. G. F. Lamb).....Edwin J. Bognar
64. A Suggestion in Teaching Economic Geology. (5 min.).....Geo. D. Hubbard
65. The Scrub Grass Coal in Ohio. (10 min.)....................Wilbur Stout
66. The Laws of Motion Under Constant Power (10 min.) (lantern) L. W. Taylor
67. A Precision Determination of the Acceleration of Gravity. (10 min.) (lantern)....................................H. Hugh Willis
68. A Quantitative Measurement of the Change in Intensity in Radio Signals During the Transition from Daylight to Dark. (15 min.) (lantern)... C. E. Howe

DEMONSTRATIONS

1. Specimens to Illustrate Paper No. 26 ....Samuel W. Chase
2. Grey Squirrel Killed by Excessive Growth of Incisor Teeth.....E. W. Schear
3. Drawings of Forster's Types of Odonata............Clarence H. Kennedy
4. Iron Bacteria from Yellow Springs, Ohio..A. C. Swinnerton and O. L. Inman
5. The Mateer Embryo. Presomite Human Embryo-Twin. (Slides and Models)...H. N. Mateer
6. One Cause of the Failure of Canada Thistles to Produce Seeds..Freda Detmers
7. Progress of the Common Barberry Eradication Campaign, 1918–1924.... John W. Baringer
8. Slides Showing Musculature of Appendages in Hexapoda......L. B. Walton
9. Biological Record Cards.................................L. B. Walton

THE INFLUENCE OF THE SUBSTRATUM ON THE PERCENTAGE OF SEX REVERSAL IN WINTER-GROWN HEMP.*

JOHN H. SCHAFFNER
Department of Botany, Ohio State University

In my paper on "The Influence of Relative Length of Daylight on the Reversal of Sex in Hemp" attention was called to the fact that apparently the substratum acts in inducing sex reversal along with relative length of the daily illumination period, by the following statement:† "A few experiments so far conducted seem to indicate that the percentage of reversal for any given length of daylight will be greater in a rich soil with abundant nitrogen than in a poor substratum low in nitrogen." Opportunity has not been available to test out completely the exact status of this observation. But it is apparently important to have a suitable substratum along with the proper length of daily illumination in order to obtain the expected sex reversal. The evidence so far obtained is, therefore, presented at the present time for the benefit of those who wish to carry on sex reversal investigations with the hemp (Cannabis sativa L.).

The highest percentages of reversal have been obtained when the hemp was planted in rich sandy loam with a rich supply of well-rotted cow manure, as stated in former papers. When hemp of the ordinary types is planted in such soil on shallow greenhouse benches with the ordinary greenhouse temperature and normal water supply, the percentage of plants showing sex reversal is roughly, inversely proportional to the relative length of daylight, ranging from 0% about the 15th of August, to 90% or over in December, to 0% again by the first of May. The reversal takes place in both directions about equally, although so far the staminate plants have shown a little higher reversal than the carpellate plants.

* Papers from the Department of Botany, The Ohio State University, No. 153.
† Ecology 4:330. 1923.

The very highest reversal for carpellate plants was from two beds planted on December 19, 1919, as follows:

1st bed—Total carpellate individuals	18.	Showing reversal,	16
2nd bed— " " "	36	" "	32
Totals	54		48

Thus nearly 89% showed sex reversal. In a bed planted December 15, 1920, with 29 carpellate plants 25, or 86+%, showed reversal.

The highest reversal for staminate plants was obtained in two beds planted respectively on December 1 and December 15, 1920.

Planted Dec. 1—Total staminate individuals	66.	Showing reversal	62
Planted Dec. 15— " " "	42	" "	39
Totals	108		101

Approximately 93½% showed sex reversal.

On January 2, 1922, duplicate plantings were made by Mr. Donald B. Anderson, graduate student, in pure quartz sand and in pure well-rotted manure. This experiment was carried on for a different purpose but the writer had the opportunity of studying these plants for sex reversal. These plantings were in deep tin trays which were immersed in water kept at a temperature of 30–35° C. The plants in the sand were provided from time to time with the following nutrient solution which was decidedly deficient in nitrogen:

Purified calcium chloride ($CaCl_2$)—4 grams in 1000 cc. water.
C. P. potassium chloride (KCL) —1 gram in 1000 cc. water.
C. P. magnesium sulfate,
($Mg. SO_4+7H_2O$) —1 gram in 1000 cc. water.
C. P. potassium nitrate (KNO_3) —.5 gram in 1000 cc. water.

On account of the nature of Mr. Anderson's experiment, it was possible to study only the staminate plants.

1. Planted in pure manure with high moisture—total staminate plants 13; showing reversal 12, pure 1.
2. Planted in pure manure with low moisture—total staminate plants 19, showing reversal 14, pure 5.
3. Planted in quartz sand with low nutrition and high moisture—total staminate plants 20, showing reversal 10, pure 10.
4. Planted in quartz sand with low nutrition and low moisture—total staminate plants 18; showing reversal 9, pure 9.

There was some mortality among these plants before blooming, but apparently not much. The original seeds and seedlings had not been counted. In these experiments, therefore, the staminate plants which survived showed the following percentages of sex reversal:

Planted in manure—
Total staminate plants 32, of which 81¼% showed reversal to femaleness and only 18¾% remained pure.

Planted in sand—
Total staminate plants 38, of which only 50% showed reversal to femaleness and 50% remained pure.

In the autumn and winter of 1922, the writer continued the experiments, but used the ordinary, variable greenhouse temperature, the trays being kept on the benches. The same nutrient solution was used for the quartz sand cultures, and distilled water was used for watering. The manure used was apparently not rotted enough at the first planting date, which caused the carpellate plants to have poor root systems and to die before they came into bloom. For this reason the first planting of November 10 was discarded. The other plantings were as follows:

1. Planted December 2 in rich cow manure. Total staminate plants 15—showing reversal 12, or 80%; pure staminate 3, or 20%.
Carpellate plants not studied.

2. Planted December 2 in quartz sand. Total staminate plants 4—showing reversal 1, or 25%; pure staminate 3, or 75%. Total carpellate plants 9—showing reversal 0, or 0%; pure carpellate 9, or 100%.
There was a high mortality among these plants before they came into bloom.

3. Planted December 20 in rich cow manure. Total staminate plants 21—showing reversal 19, or 90+%; pure staminate 2, or 9+%.
Carpellate plants not studied.

4. Planted December 20 in quartz sand. Total staminate plants 12—showing reversal 3, or 25%; pure staminate 9, or 75%. Total carpellate plants 17—showing reversal 0, or 0%; pure carpellate plants 17, or 100%.

In all of these sand experiments there was considerable mortality; so if the plants that are capable of reversal under the given environment have a greater mortality than those which have a more persistent sexual state, the ratios would be somewhat modified. But this is not probable.

Taking into account the time of the year in which the planting was done the average reversal for the staminate plants should have been about 90% and for the carpellate plants about 83% if planted in rich, well manured soil. The plants in the pure manure approached these figures in spite of a rather high mortality in this substratum.

But the average reversal for the 34 staminate plants in the sand was only 33% and among the total of 26 carpellate plants in the sand cultures studied, there was no sex reversal whatever. Part of this result was probably due to the high mortality among the carpellate plants after they began to bloom and before the individuals had time to change their sex in any flower buds produced. It must be remembered that usually the great majority of carpellate plants are much more tardy in showing sex reversal than the staminate plants, and are, therefore, less favorable objects for study, when grown in very sterile soils, than the staminate plants.

As stated above, the 68 staminate plants grown to maturity in the pure manure cultures showed nearly 84% reversal to femaleness, approximating the 90% or more usually obtained when the plants are grown on the greenhouse benches in well manured sandy loam at the same season of the year.

It is thus evident that although a primary cause of sex reversal in hemp is the relative length of daylight and darkness during the 24 hours, the percentage of reversal and even the very possibility of reversal depends to a considerable extent on whether the plant is drawing the proper nutrients, especially nitrogen, from the substratum at the time.

The reversal of sex is probably brought about by a physiological condition dependent in some way on the carbohydrate-nitrogen ratio in the cells. Gardner* in his studies in the nutrition of bisporangiate strawberries (Senator Dunlap) as related to yield, came to the following conclusions in regard to the sex development and reversal which appeared in his cultures: "Low carbohydrate and low starch content at the time of fruit bud differentiation led to the production of female flowers in a variety that normally is hermaphroditic." "It is suggested that variations in the relative carbohydrate content are responsible for changes in sex development, low carbohydrate content

* Gardner, V. R. Studies in the Nutrition of the Strawberry. Univ. of Missouri Agr. Sta. Research Bull. 57:1-32, March, 1923.

being associated with the female condition, high carbohydrate content with hermaphroditism." This of course might be true for the bisporangiate-flowered strawberries and not necessarily for other types of plants.

Apparently the Senator Dunlap Strawberry, Arisaema triphyllum (L.) Torr., and Cannabis sativa L. are each good species for studying the relation that may exist between the substratum, the carbohydrate-nitrogen ratio of the protoplast, and the sex determination and sex reversal that occur so readily with the proper environment in these plants. Physiological ecology must soon take its place as a fertile field of research among its sister divisions in the botanical field if we are to obtain a better understanding of the great and fundamental problems presented by living things.

OHIO MOSSES, POLYTRICHIALES*

NELLIE F. HENDERSON,
East High School, Columbus, Ohio

Among the students of Ohio mosses, most of whose work was done a number of years ago, may be mentioned William S. Sullivant, Leo Lesquereux, H. C. Beardslee, W. C. Werner, A. P. Morgan, Miss H. J. Biddlecome, W. A. Kellerman and Edo Claassen. The last named has made a rather extensive study of the mosses of northern Ohio. About 250 species of mosses have heretofore been reported from Ohio and there may be many more not yet reported. This is exclusive of the Sphagnums. Otto E. Jennings has made an extensive study of the mosses of western Pennsylvania and his work is of great value in a study of the Ohio mosses, as many of the species listed in his publications are found also in Ohio. So far as the writer knows, no special or complete study of the Ohio mosses has been made. The present paper is a preliminary study of the order Polytrichiales. The nomenclature used agrees with the law of priority and where characteristics could not be verified from the specimens themselves, only those have been used which are noted by all authors as being fixed. For identification both the gametophyte and the sporophyte have been used as the keys have been constructed so that identification could be made with the use of only a hand lens. To make the identification from the gametophytes alone sections and a compound microscope would be necessary. The distribution indicated for each species is based on specimens in the Ohio State Herbarium unless otherwise indicated.

At the suggestion of Professor John H. Schaffner, under whom this work was carried on, the terms perigonium and perigonial scales are used for both the archegonial and antheridial branches.

POLYTRICHALES.

Mostly unisexual mosses, acrocarpous, ours mostly little or not at all branched, rising either directly from the protomema or from a subterranean rhizome-like stalk. Sporangium with a definite columnella.

* Papers from the Department of Botany, the Ohio State University, No. 156.

Peristome teeth solid, single, or double, or rarely absent. Always present in our species. Teeth are developed from two layers of the sporangium, and consist of entire cells; not transversely barred; or if developed from the thickened parts of the cell walls, then the sporangium is decidedly dorsiventral.

Synopsis of the Order.

I. Peristome of 4–6 teeth; sporangium erect, actinomorphic; small mosses. (Tetraphidaceæ). Tetraphis. (1) pellucida.
II. Peristome of numerous teeth; sporangium actinomorphic or zygomorphic.
  A. Sporangium actinomorphic; gametophytes large. (Polytrichaceæ).
    1. Calptra smooth. Catharinea (2) crispa, (3) angustata, (4) papillosa, (5) plurilamellata, (6) undulata.
    2. Calyptra hairy.
      a. Sporangium cylindrical. Pogonatum. (7) pennsylvanicum.
      b. Sporangium angled. Polytrichum. (8) ohioensis, (9) gracile, (10) commune, (11) juniperinum, (12) alpestre, (13) piliferum.
  B. Sporangium zygomorphic, gametophytes small. (Buxbaumiaceæ).
    1. Sporangium only slightly zygomorphic, nearly sessile; scales present. Diphyscum. (14) foliosum.
    2. Sporangium decidedly flattened and dersiventrally differentiated; with a short seta; scales disappearing entirely. Buxbaumia. (15) aphylla.

Key to the Families of Polytrichales.

1. Peristome teeth 4–6, sporangium actinomorphic; small mosses. Tetraphidaceæ.
1. Peristome teeth 32–64, sporangium actinomorphic or zygomorphic. 2.
2. Sporangium actinomorphic; large mosses. Polytrichaceæ.
2. Sporangium zygomorphic; gametophyte very small. Buxbaumiaceæ.

TETRAPHIDACEAE.

Gametophytes small and gregarious, forming dense mats. Scales ovate or lanceolate, smooth, margins entire, costa extending nearly to the tip. Peristome of four solid teeth formed from all the tissue enclosed within the operculum. Sporangium cylindrical, smooth, erect; hypophysis tapering, no stomata.

1. *Tetraphis* Hedw. (Georgia Ehrh.)

Gametophytes slender, brownish, branched, stalks 3-angled, gemmæ borne at tip of branches in a cup formed of four or five broad scales.

1. *Tetraphis pellùcida* (L.) Hedw. (Georgia pellucida Rabenhorst). Gametophytes forming yellowish-green tufts, brownish below, one-half to one inch tall, branches of two kinds, those bearing stalked gemmæ and the fertile branches which occasionally bear two sporophytes. Seta straight, slender, brown, one-half to three-fourths inch long; sporangium slender, erect; calyptra covering the upper one-third. Spores mature in late summer, but the capsules persist through the winter. Found on decaying wood, or in swamps on soil rich in organic matter.

This is the only common moss having the 4 peristome teeth. Specimens from Fairfield, Champaign, and Lawrence Counties. Reported from Cuyahoga, Portage, and Summit.

POLYTRICHACEAE.

Large mosses growing mostly on the soil, cespitose; branches simple or branched, from a rhizome. Upper scales large, clasping, lanceolate or ligulate, with the ventral surface bearing few to numerous lamellæ one cell in thickness and several cells high. Lower scales much smaller and not lamellate. Antheridia borne in a large discoid cup at the tip of a branch which may later renew its growth. Seta long; sporangium erect, later becoming inclined or pendulous. Peristome teeth numerous, short, attached by their tips to the expanded top of the columnella. Calyptra cucullate.

1. Calyptra smooth...Catharinea.
1. Calyptra hairy. 2.
2. Sporangium cylindrical..Pogonatum.
2. Sporangium 4–6 angled..Polytrichum.

1. *Catharínea* Ehrh. (Atrichum Beauv.)

Scales crisped when dry, margins serrate, not sheathing the stalk. Sporangium smooth, cylindrical or oval, more or less curved. Calyptra without hairs, but is spinulose-papillose at the apex. Operculum long-beaked. Peristome teeth 32, with a rust-colored median line.

1. Scales oval-oblong; lamellæ 1–4, low and indistinct; sporangia obconical, C. crispa.
1. Scales ligulate. 2.
2. Sporangia strongly arcuate, cylindrical............................C. undulata.
2. Sporangia inclined, oblong...C. angustata.

1. *Catharinea críspa* James. (Atrichum crispum Sull.). Gametophytes form yellowish-green tufts; stalks unbranched, 2–4 inches high; scales distant, oval-oblong or oblong-lanceolate, lamellæ 1–4, low, vanishing toward base of scale, scarcely undulate; lower scales smaller and broader. Often two or three sporophytes grow together. Sporangia only slightly curved, obconical.

Rare. Found in beds and on sides of rocky streams, in sand or among grass. Clinton County.

2. *Catharinea undulàte* (L.) Weber and Mohr. (Bryum undulatum L., Atrichum undulatum Beauv.). Gametophytes in loose, dark green patches, yellowish when in open dry spots.Stalks simple or branched from a much branched rhizome, 1–2 inches tall. Scales very small below, gradually larger above; upper ones ligulate, strongly undulate; lamellæ 2–6, covering one-eighth to one-fourth of the width of the upper part of scale. Sporophytes often two or more from one perigonium; seta reddish-brown, 1–1¼ in. long; sporangium strongly arcuate, cylindrical.

A common moss on shady clay or sandy banks.

3. *Catharinea angustàta* (Bridel.) Bridel. (Polytrichum angustatum Schw., Atrichum angustatum, B. & S.). Loosely cespitose, dull green, one-third to one inch tall. Scales linear-lanceolate, lamellæ and costa

occupying more than one-fourth width of scale; lower scales minute. Seta erect, brown; sporangium brown, linear, cylindrical, slightly curved. On shady banks, often under hemlocks.

Rather general in Ohio.

Jennings has described two new species found in Western Pennsylvania and these are probably found in Ohio. They vary from *C. angustata* only in the number and height of the lamellæ and may be forms of *C. angustata*. They are distinguished as follows:

C. angustata—Lamellæ 5–8, 6–8 cells high, covering one-fourth to one-half of upper scale width.
C. papillòsa Jenn.—Lamellæ 6–8, 8–14 cells high, covering one-half to two-thirds of upper scale width.
C. plurilamellàta Jenn.—Lamellæ 7–12, 8–14 cells high, covering two-thirds to three-fifths of upper scale width.

2. *Pogonàtum* Beauv.

Gametophytes gregarious, erect, upper scales somewhat clasping. Sporangium erect, cylindrical, without stomata, hypophysis tapering. Calyptra mitrate, densely hirsute and somewhat shaggy, hairs covering the entire sporangium. Peristome teeth, 32.

1. *Pogonatum pennsylvànicum* (Hedw.) Paris. (Polytrichum pennsylvanicum Hedw., Pogonatum brevicaule Beauv., Pogonatum tenue F. G. Briton, Polytrichum tenue Menzies). Gametophytes scattered on a green felt-like protonema, very short, less than one-eighth inch. Scales acuminate, serrulate, lamellate. Seta yellowish or reddish; Calyptra light yellow; operculum beaked. On shady clay banks. Fruits in late autumn.

Specimens from Franklin and Lawrence Counties, and Claassen reports it from Cuyahoga and Lake.

3. *Polytrichum* Dill. Haircap Mosses.

The largest of our mosses, tufted, stiff, green or bluish-green. Scales not sheathing, lamellæ and costa occupying the greater part of the outer part of scales; costa often extending in an awn. Sporangium 4–6-angled, cubic to oblong. Calyptra covered with dense shaggy hairs which extend below base of capsule. Generally 64 peristome teeth.

1. Margins of scales broad, entire, and inflexed. 3.
1. Margins of scales serrate, not inflexed. 2.
2. Hypophysis with constriction above, disk-like; sporangium cubical, with short beak...P. commune.
2. Hypophysis not constricted above; sporangium longer than broad, P. ohioensis.
3. Costa ex current, forming a long hyaline awn, rough; plants small and simple, in dry places...P. piliferum.
3. Costa only slightly or not at all excurrent, red; plants larger. 4.
4. Stalks densely tomentose below; sporangium cubic; scales erect..P. alpestre.
4. Stalks not at all or only slightly tomentose; sporangia oblong; scales spreading...P. juniperinum.

1. *Polytrichum ohioênsis* Ren. and Cand. Ohio Hair-cap. Loosely cespitose, olive-green, gametophytes erect; 1–6 inches tall; stalks stiff, brown. Upper scales sheathing, spreading when moist, costate, 40–50 lamellæ. Sporophyte erect, seta brown, 1½–2½ inches long; sporangium erect when young, becoming inclined when older, elongated, slender; tapering, not constricted above, hypophysis calyptra not covering sporangium; operculum long-beaked. Spores ripe in June. Common; in moist, shady places.

Polytrichum grácile Dicks, is a form very similar to *P. ohioensis* and doubtless often confused with it. The characteristics of the two as described overlap and are variable. The terminal cell of the lamellæ of *P. gracile* in cross-section is rounded, while that of *P. ohioensis* is notched.

2. *Polytrichum commùne* L. Common Hair-cap. Gametophytes similar to *P. ohioensis*, but larger, 6–18 inches, our largest moss. Seta 2½–4 inches long, brown. Sporangium almost cubic; hypophysis distinct, constricted above, operculum with a short beak; calyptra light yellow, extending to below the sporangium. Spores mature in mid-summer. In open fields or woods.

Williams and Licking counties. Claassen reports it from Cuyahoga, Geauga, Lake, and Portage.

3. *Polytrichum junipêrinum* Willd. Juniper Hair-cap. Plants scattered, erect, 1–4 inches, light green, slightly tomentose at the base. Scales lanceolate, sheathing, inflexed, entire, spreading when moist, costa excurrent to form a short dentate, red arista; lamellæ 35–40. Seta 1½–2½ inches long, red; sporangium tetragional-oblong, sharply angled, operculum red with a short beak, hypophysis rather indistinct. Spores mature in mid-summer. In dry pastures or open woods.

Rather common.

4. *Polytrichum alpêstre* Hoppe. (Polytrichum strictum Banks). Resembles *P. juniperium*, except it grows in dense matted tufts, grayish-white tomentose; slender, terete, up to one foot tall. Scales entire, erect, sheathing; costa protruding to form a red, serrate arista; lamellæ 25–30. Seta 1½–2½ in. long; sporangium cubic brown; hypophysis distinct; calyptra covering the capsule; operculum flat. Spores mature in mid-summer. Bogs.

Has not been reported from Ohio, but may be present as Jennings lists it from western Pennsylvania.

5. *Polytrichum pilíferum* Schreb. Loosely tufted, light green, somewhat glaucous. Gametophytes simple, erect, 1–1½ inches tall; scales only on the upper part of the stalk, ascending when moist, lanceolate, entire, margins inflexed, ending in a long, hyaline, white awn.

Seta 1–1½ inches long; sporangium sharply 4-angled, usually horizontal when mature; hypophysis constricted above; operculum with a short beak, stout; capytra covering the sporangium. Spores mature in mid-summer. On dry, sandy soil or rocky ledges.

No specimens, but is reported by Kellerman.

BUXABAUMIACEAE.

Very small mosses with the protonema often persistent. Sporangium zygomorphic, oblique and dorsiventrally asymmetrical, very large in proportion to the remainder of the plant; calyptra very small; peristome of one or two layers, outer teeth, when present, very faintly barred.

1. Scales persistent, exceeding the sporophyte in length; seta almost or quite absent .... Diphyscum.
1. Scales deciduous; seta distinct .... Buxbaumia.

1. *Diphyscum* Mohr.

Low, gregarious perennials with a long, persistent protonema. Scales dense, spreading when moist, ligulate or lanceolate, entire; perigonial scales longer, erect, membraneous; costa long aristate. Seta very short; sporangium immersed, mouth very small.

1. *Diphyscum folìòsum* (Webr.) Mohr. (Webera sessilis Lind., Buxbaumia foliosa Weber). Plants form a dense dark green mat; many sterile plants. Seta almost or entirely absent, sporangium light brown, resembling a grain of wheat, apex curved, pointed; inner peristome white, later brown. Found on moist clay banks where there is little or no other vegetation, and usually associated with a white lichen.

Reported by Claassen from Cuyahoga County.

2. *Buxbaùmia* Haller.

Antheridial plants microscopic, having a single scale enclosing one stalked antheridium; archegonial plants with only a few minute, deciduous scales, without chlorophyll. Seta rough, stout; sporangium conspicuous, oblique, dorsiventral.

1. *Buxbaumia aphylla* L. Protonema persistent, forming a brownish mat. Seta purplish, about one-half inch long; sporangium glossy, brown, almost horizontal, flattened above. Spores scattered by the splitting of the capsule. Capytra minute; perisome present. On ground or rotten wood. Spores mature in late fall and early spring. Rare.

Perry County. Is also reported from Jacob's Ladder, Fairfield County, by Miss Clara G. Mark.

SYNAPSIS CONSIDERED AS A SEXUAL PHENOMENON.*

JOHN H. SCHAFFNER,
Department of Botany, Ohio State University.

The first decade of the 20th century witnessed the establishment of the theory of the individuality of the chromosome, through numerous cytological investigations, on a firm basis of fact. The acceptance of this deduction had and still has a most profound influence on biological theory. The discovery by Montgomery (8) and others that the bivalent chromosome is actually made up of a pair of univalents, one from the maternal and one from the paternal side, laid the cytological basis on which genetics can be substantially built. But in recent years it has been found that many irregularities in conjugation and segregation occur, which shows that the properties of the chromosomes that cause them to unite and separate are properties that may appear and disappear regularly or irregularly in the life cycle. This property of specific attraction at a single special point in the life cycle is appropriately considered as a second development of primary sexual states, the first being in the gametes themselves. The specificity of the chromosomes in relation to synaptic attraction is far more remarkable then the fact of individuality of material and form.

Most cytologists have been impressed by the peculiarities of the reduction division. But the reduction division shows no special deviation from ordinary vegetative karyokinesis except as it is modified by the synaptic properties of the chromosomes during the prophase and metaphase stages. The writer worked out the details of the reduction division long before he knew what relation these chromosome shiftings had to heredity or what the actual probable cause was for the peculiar deviations from the vegetative divisions. (10). Several re-examinations of the original materials have reassured him that his first interpretation of the figures was essentially correct, and gave the proper basis also for the later developed facts of Mendelian heredity.

* Papers from the Department of Botany, The Ohio State University. No. 160.

A comparison of the sexual conjugations of gametes with the conjugations of synaptic pairs of chromosomes shows that the phenomena are alike in many respects and tends decidedly to the conclusion that the synapsis of specific pairs of chromosomes is due to the presence in them of primary sexual states of the same nature as the primary sexual states of the entire protoplasts, including their nuclei, i. e., of gametes, and which cause them to be attracted to each other and thus associated during the diploid stage of the organism. Just as there is more or less specific compatibility or indifference in the conjugation of gametes so also is there a specific compatibility or aversion of chromosomes of the same set to conjugate or of different sets in the case of extreme hybrids. The characteristics and peculiarities of isogamous gametes and the various degrees of heterogamous gametes are also paralleled to a certain extent although not entirely by the evolution of allosomes in some organisms. From this point of view a sexual organism has two stages in its life cycle in which primary sexual states arise. In one stage (gamete stage) the entire protoplast, but more especially the entire nucleus, which is normally haploid, becomes + or − in relation to another protoplast; in the other stage (reduction or synapsis stage) the chromosomes become + or − in relation to each other individually, without any special reference as to whether the sporocytes are for the time being in the secondary male or female state, namely are microsporocytes or megasporocytes, or are in a neutral condition as for example in homosporous plants. This sexual union of synaptic mates was suggested in a general way in 1908 but up to the present has not been developed further by the writer. (Schaffner 13).

In case of polyplody the normal sequence of events may, of course, be considerably changed. Belling found that in triploid Cannas (1) the three chromosomes of each kind or set come together. Multiple conjugation of chromosomes is possible just as triple fusion or other multiple fusions of nuclei in the gametophytes of Angiosperms.

In many species synapsis first becomes manifest by the development of the protochromosomes. In this early stage evidently the individual chromosomes must be attracted into their appropriate synaptic pairs and in the ordinary types of karyokinesis this is the only time when such proper association

is possible; and we know that the chromosomes are properly paired off both from the consequent Mendelian behavior and from direct cytological evidence as first definitely shown by Montgomery (8). Were there no cytological evidence for the individuality of the chromosome and for definite synaptic mates we would be compelled by the genetic evidence to hypothecate such a condition in spite of the so-called crossing over of hereditary factors. But the evidence for individuality and specific synaptic mating in normal reductions is convincing. The genetic evidence properly interpreted and the cytological evidence are in accord. The peculiar notion of a parasynapsis by which two complete threads each made up of a chain of chromosomes, are supposed to come to lie side by side for the entire length of the chain during synizesis requires a mechanism and activity of the chromatin entirely outside the method of behavior of the nucleus in the vegetative karyokinesis.

The first division of meiosis or the true reducing division proceeds then along the same lines as an ordinary nuclear division except that the pairs of chromosomes become sexualized in relation to each other and are associated first as protochromosomes. From this stage on they elongate, join end to end in a continuous chain as in any vegetative division, and produce a thread with a single row of chromatin granules which later divide and form the double spirem. It is this enlarged state of the nucleus with its extended and delicate, continuous thread that shows synizesis in ordinary microscopic preparations. At the stage when the spirem has the double row of chromatin granules and when it is much thicker there is usually no synizesis unless the material has been very poorly killed. The sexual attraction continues very strong between the synaptic mates, holding them in telo-synapsis at the point of union of the pairs much more strongly than the union with the next pair in the skein, as shown by the subsequent behavior. After the forces which produce the extended spirem and which apparently act in opposition to the synaptic attraction are expended and the spirem is shortening and developing the chromatin loops the synaptic attraction again acts very strongly and throws the mates into longitudinal often twisted loops or fold, into the true para-synaptic position. Next the force that has held the chromosomes together in a continuous chain disappears just as in a vegetative division and the chromosomes fall apart except

at the ends where the pairs were originally held together in telosynapsis in addition to the ordinary union. The sexuality of the synaptic mates becomes much intensified at this stage resulting in such a close union of the bivalents and their daughter halves that they usually appear like single chromosomes. But just as the primary sexual state disappears in the united gametes when the nuclei have fused so the synaptic mates lose their + and − condition and by the time they have been brought into the mother star with the spindle fibers properly attached, they normally become promptly and completely desexualized and are separated to the opposite poles much like daughter chromosomes are in vegetative karyokinesis, except that each univalent is made up of two longitudinal daughter halves as it arrives at the pole. However, sometimes the attraction continues beyond the usual stage in some synaptic pair, resulting in irregular chromosome distributions. The sexual state of the synaptic mates may also disappear too early, again making abnormal distributions possible. As indicated, the segregated univalents are already in the longitudinally divided condition and this probably is the cause of the prompt development of the second spindle, often before the nucleus has advanced very far toward the resting condition. The second division of meiosis is, therefore, a necessary consequence of the modification of the karyokinesis brought about by the synapsis of the chromosomes in the first division.

The reduction division is then an ordinary division modified by the development of primary sexual states in the individual chromosomes, leading them into synapsis and there is apparently nothing peculiar in the reduction division except what is consequent to the sexualization of the synaptic mates. There is nothing mysterious in the reduction division itself but, as Strassburger pointed out long ago, it is a necessary consequence of fertilization if a sexual organism is to perpetuate a working or workable mechanism. The mystery at present lies with the sexual states, both primary and secondary. The important peculiarities which are the result of sexualization are first, the concentrations and movements of the chromatin giving rise to the protochrosomes, often rather definite masses; second, the strong bond of union in telosynapsis of the synaptic mates; and third the further attractive process at the looping stage by which the two fused chromosomes are drawn together in a close

lateral union or parasynapsis, which for a time may entirely obliterate any indication of the actual duality of the structure.

Karyokimeses in which there is no sexualization of the chromosomes, whether taking place with haploid, diploid, triploid, or tetraploid complements of chromosomes are essentially the same in character. But the presence of a multiple set or complement of chromosomes greater than diploid must necessarily give rise to possible new Mendelian ratios or to abnormal deviations.

The writer first discovered the important processes in the reduction division in Lilium philadelphicum (10) in 1897, and later in Erythronium in 1901 (11), in Lilium tigrinum in 1906 (12), and in Agave virginica in 1908 (13). In 1905 Mottier (9) found the process essentially the same in Podophyllum peltatum; and Miss McAvoy's study of Fuchsia (6) and of Oenothera biennis in 1913 (7) showed that a similar succession of stages was present in these species, and not merely a telosynapsis as reported for "Lamarckiana" mutants by Gates (3 and 4) and others. From 1903 on a large number of investigators, especially Farmer and Moore (15), confirmed the earlier conclusions. DaCruz (2) found a very beautiful series of figures in Lilium tenuifolium. In the meantime the "parasynaptists" were writing another story. But any one acquainted with the cytology of the higher plants knows that there are no two normal types of reduction as represented by "telosynaptists" and "parasynaptists." It is a matter of divergent psychology or rather cytological cults or sects. But as stated in the beginning, in the higher plants at least, when the reduction is normal, there is both telosynapsis and a real parasynapsis. There are no two types in Lilium for example; the one group of priests or the other is worshiping a false god. According to the Morgan scheme of crossing over, a very definite telosynapsis is demanded if the scheme is to work; for in the following parasynapsis the corresponding parts of the chromosomes must always be in juxtaposition. If the chromosomes are differentiated as to the two ends such a definite mode of telosynapsis may normally take place. But such a method of crossing over as proposed by the Morgan school of geneticists appears too impossible to be taken seriously at the present time. Crossing over can be explained on entirely different assumptions which agree much better with the cytological evidence.

In case of incomplete sexualization of the synaptic mates, parasynapsis may be absent or nearly so. This appears to be the case in the parthenogenetic diploid Leontodon (Taraxacum) as reported by Sears (14). Sears has described under the term "Ameiosis" a process in which the univalents are slow in pairing. "Synaptic pairing is end to end but takes place so slowly that spindle fibers become attached to each of the halves of each univalent instead of the univalents as a whole. In consequence the pairs come to metaphase thirteen in number, but with components still end to end and transversely oriented. . . . The division is qualitative, if ordinary canons be right." Here it is evident that chromosomes in synapsis may begin to lose their primary sexual states before synapsis is complete. In extreme cases synapsis might become so intense and be so prolonged that non-disjunction would result.

That partial loss of the property of sexualization of the chromosomes in reduction may be an important cause in the increase of chromosome numbers is strongly indicated by the discoveries of Longley and Darrow (5) in raspberries. They found that all the raspberries studied by them can be separated into two groups; those with seven haploid chromosomes and those with more than seven. Furthermore, they found that the typical species with seven haploid chromosomes have their somatic univalents pairing very promptly in the prophase of the first reduction division and that these bivalent chromosomes divide regularly and promptly in both the first and second divisions. Sometimes however, in rare cases, there was a little tardiness in pairing of univalent chromosomes, or occasionally a single chromosome lagged behind its associates in reaching the pole. They also found that the polyploid raspberries showed characteristic irregularities in the distribution of their chromosomes during meiosis. In these, prompt pairing of the chromosomes in reduction was absent. There were irregular distributions of the chromosomes, some of which lagged on the spindle and were extruded from the daughter nuclei. The authors believe that such behavior indicates a hybrid origin. There is probably both specific incompatibility and imperfect sexualization due to the hybrid condition of the nuclei.

There is probably no question but that incomplete sexualization of any set or of any complete complement of chromosomes,

leading to incomplete synapsis is one of the several causes of the origin of polyploid sets and complements of chromosomes.

Whether there is a partial loss of the synaptic property in certain Oenothera lamarckiana mutants which might modify the later part of the process of synaptic union and thus account for the slight discrepancy in the reduction as reported by Gates on the one hand and by Miss McAvoy for OE. biennis and Fuchsia on the other is a question that only further, careful cytological studies can answer.

LITERATURE CITED.

1. BELLING, J.
   The Behavior of Homologous Chromsomes in a Triploid Canna. Proc. National Acad. Sci. 7 : 197–201. 1921.
2. DA CRUZ, DANIEL.
   A Contribution to the Life History of Lilium tenuifolium. Catholic University of America. Washington, D. C. 37 pp. 1915.
3. GATES, R. R.
   Pollen Development in Hybrids of Oenothera lata X Oenothera lamarckiana in its Relation to Mutation. Bot. Gaz. 43 : 81–115. 1907.
4. GATES, R. R.
   A Study of Reduction in Oenothera rubrinervis . Bot. Gaz. 46 : 1–34. 1908.
5. LONGLEY, ALBERT E. AND DARROW, GEORGE M.
   Cytological Studies of Diploid and Polyploid Forms in Raspberries. Jour. Agr. Res. 27 : 737–748. 1924.
6. McAVOY, BLANCHE.
   The Reduction Division in Fuchsia. Ohio. Nat. 13 : 1–18. 1912.
7. McAVOY, BLANCHE.
   The Reduction Division in the Microsporocytes of Oenothera biennis. Ohio Nat. 14 : 189–197. 1913.
8. MONTGOMERY, JR., T. H.
   Some Observations and Considerations upon the Maturation Phenomena of the Germ Cells. Biol. Bull. 6 : 137–158. 1904.
9. MOTTIER, D. M.
   The Development of the Heterotype Chromosomes in Pollen Mother-cells. Bot. Gaz. 40 : 171–177. 1905.
10. SCHAFFNER, JOHN H.
    The Division of the Macrospore Nucleus. Bot. Gaz. 23 : 430–452. 1897.
11. SCHAFFNER, JOHN H.
    A Contribution to the Life History and Cytology of Erythronium. Bot. Gaz. 31 : 369–387. 1901.
12. SCHAFFNER, JOHN H.
    Chromosome Reduction in the Microsporocytes of Lilium tigrinum. Bot. Gaz. 41 : 183–191. 1906.
13. SCHAFFNER, JOHN H. The Reduction Division in the Microsporocytes of Agave virginica. Bot. Gaz. 47 : 198–214. 1908.
14. SEARS, PAUL B.
    Variations in Cytology and Gross Morphology of Taraxacum. Bot. Gaz. 73 : 308–325. 1922.
15. FARMER, J. B., AND MOORE, J. E. S.
    New Investigations into the Reduction Phenomena of Animals and Plants. Proc. Roy. Soc. London 72 :.104–108. 1903.

THE DRAGONFLY, TACHOPTERYX THOREYI, RECORDED FOR OHIO, WITH NOTES ON ITS NEAR RELATIVES.

JAMES S. HINE

Department of Zoology and Entomology, Ohio State University

From time to time we have reported additions to the list of Ohio dragonflies enumerated in Dr. Kellicott's paper published by the Ohio Academy of Science in March, 1899. The last published addition appeared in the *Ohio Journal of Science*, Volume XIV, page 219, and recorded the capture of anax longipes, at Sandusky, Ohio, by Mr. Rees Philpott.

An interesting addition to the known odonat fauna of the State is known to Science as Tachopteryx thoreyi Selys. Three specimens have been procured. A female was taken at Ira, Summit County, Ohio, June 20, 1921, by my daughter, Dorothy, who found it resting on the side of a building. A second female was taken in the same locality and by the same collector on July 20, of the same year. This latter specimen was first observed flying about a pool of slack water in a small creek and attempted to alight on the collector, but being prevented from doing so, came to rest on the trunk of a beech tree near by, where it was procured very easily with the aid of an insect net. On August 11, 1923, I was walking along a highway near Sugar Grove, in Fairfield County, when a male specimen was observed flying leisurely before me. It soon alighted on bare ground and I succeeded in capturing it with a net without great effort.

The species has been considered as a likely member of Ohio's fauna for a long time, for Williamson procured it in both Pennsylvania and Indiana nearly twenty-five years ago. Special significance attaches to the species, for it is considered as one of the members of a primitive group, which is supposed to have had numerous representatives in both species and individuals widely distributed over the world. More recently conditions seem to have been less favorable for their requirements for a once dominant group is now reduced to a few scattered species, apparently with a somewhat limited number of individuals belonging to each.

If all specimens of the subfamily are as easily procured as those taken in Ohio, surely they cannot be considered wary, and perhaps a suggestion is evident as to why the group is declining and possibly in danger of becoming extinct.

Tachopteryx thoreyi Selys is classified in the subfamily Petalurinæ, which includes nine known species, distributed in five genera.

PETALURA Leach is known only from Australia and contains three species, *gigantea* Leach, *ingentissima* Tillyard, and *pulcherrima* Tillyard. The second species has been mentioned as the largest dragonfly in the world, and if it does not hold this record, it approaches it closely, for some specimens have an expanse of six and one-half inches and a total length of five inches.

UROPETALA Selys is peculiar to New Zealand, so far as known, and contains two species, *carovei* White and *chiltoni* Tillyard. The species of this genus have an expanse of about four inches.

TACHOPTERYX Selys, as now restricted, contains only one species, *thoreyi* Selys. It is not known to occur beyond the limits of the United States, but has been collected in New York, Pennsylvania, Maryland, Kentucky, Indiana, Ohio, North Carolina, Texas and Florida.

TANYPTERYX Kennedy is a generic name proposed a few years ago in a valuable paper entitled "Notes on the Life History and Ecology of the Dragonflies (Odonata) of Central California and Nevada," by Dr. C. H. Kennedy, for the reception of *hageni* Selys from Western United States, and *pryeri* Selys from Japan.

The type locality for *hageni* is Nevada, but specimens are known also from Washington and California.

PHENES Rambur contains only one species, *raptur* Rambur, from Chile. Very little literature concerning this species has appeared.

The widely scattered distribution of the few existing species is advanced as one of the proofs that the Petalurinæ formerly was an important factor in the dragonfly fauna of the world, but has declined, so that the representatives of the group now known may be considered as remnants that have become pocketed in these isolated localities.

The well known authority on dragonflies, E. B. Williamson, was the first to publish regarding the metamorphosis of a

member of the subfamily. In his paper in *Entomological News*, Volume XII, page 1, he records the capture of a nymph of Tachopteryx thoreyi and gives a full description and a figure of the specimen from which an adult female was reared.

Later Dr. R. J. Tillyard,. of New Zealand, formerly of Australia, made a notable contribution to the knowledge of life histories of dragonflies when he published the results of his work on Petatura gigantea in the Proceedings on the Linnaen Society of New South Wales, in 1909 and 1911. He succeeded in finding nymphs of various sizes and ages in plentiful numbers. They burrow in the mud of swamps, where but little water is standing. The burrows were observed to go down two or three-feet in depth and to be connected with cross burrows in such a way as to form a complex which several nymphs use as a retreat. Tillyard concluded that these nymphs probably leave the burrows at night to procure food and possibly when they change from one instar to the next.

The latter observer in a paper in the Transactions of the New Zealand Institute for 1921 gives the reproduction of a photograph of the nymph of Uropetala carovei and a few notes concerning the species.

Previous observations have associated the species of this subfamily studied, with marshy areas where not much water stands, such as are found surrounding the outlet of springs that issue at a level somewhat higher than an adjacent stream bed, but where the flow of water is more or less retarded by the lay of the land and by the growth of vegetation and the collection of derived material. It is very likely that where such an area is available for breeding grounds, Tachopteryx thoreyi may be found flying in season in the vicinity. It is like many other species of animals with a particular habitat. They are plentiful enough when one knows where to look for them.

THE GENUS DEBARYA.

EDGAR NELSON TRANSEAU
Department of Botany, Ohio State University

The taxonomic history of the *Zygnemales* is characterized by more, or less, futile attempts to use the chromatophores, the various types of conjugation and reproduction, the characters of the spores, or the methods of gamete formation as the basis of classification. The splitters have had their innings and have postulated numerous genera which later on had to be abandoned because of the discovery of new species which were intermediate, or which exhibited two or more conflicting generic characters. The history of the genus *Mougeotia* is a striking example, which as now understood includes *Mesocarpus*, *Craterospermum*, *Plagiospermum*, *Staurospermum* and *Gonatonema*.

The various groupings into families and subfamilies have been equally various and futile, and the best scheme at the present time seems to be to consider the *Zygnemales* as an Order of the *Akontæ* co-ordinate with the *Desmidiales*. The Order Zygnemales consists of a single family: the Zygnemaceæ. This family includes 6 genera: *Debarya*, *Mougeotia*, *Temnogametum*, *Pleurodiscus*, *Zygnema*, and *Spirogyra*. Altogether about 200 valid species have been described. Under this arrangement the natural relationships of the species and genera are more readily visualized, and certainly less obscured than by the use of a larger number of arbitrary subdivisions.

The genus *Debarya* was founded by Wittrock in 1872 to more definitely classify the "Mougeotia glyptosperma" described and figured by De Bary in 1858. There are two outstanding features of this alga: (1) the form of the zygospore is absolutely unique among the known *Zygnemales;* and (2) as the gametes form and contract toward the conjugating tubes pectic compounds and cellulose accumulate within the gametangia replacing them. The chromatophore is quite similar to that of *Mougeotia*. In 1894 Palla described "Mougeotiopsis calospora" as a new genus and species which resembles *Debarya* in the solidification of the gametangia but which differs from *Debarya* in the apparent absence of pyrenoids. In 1898 W. and

G. S. West questioned the validity of this observation and of its use as a generic character, and in 1900 renamed it *Debarya calospora* based on material collected in Yorkshire which had pyrenoids. In 1897 the Wests also transferred to this genus the "Zygogonium læve," described by Kuetzing in 1849, as *Debarya lævis*. In both these species the cell shape is more that of a *Zygnema* than of a *Mougeotia*, and the chromatophores are rather indefinite structures with two, three, or several pyrenoids only remotely resembling *Mougeotia*. In 1903 the Wests added a fourth species, *Debarya desmidioides* with short cells and indefinite rod-shaped chromatophores, each with two distinct pyrenoids.

Debarya americana was described by the writer in 1915. This species has cells and chromatophores intermediate between *Mougeotia* and *Zygnema*. The chromatophores are usually definite and platelike with two pyrenoids but at the time of conjugation often thickened around each pyrenoid and more or less dumbbell-shaped. In the latter condition these chromatophores are quite similar to those of *Zygnema vaucherii* Ag. var. *stagnale* (Hassall) Kirchner.

At the same time *Debarya decussata* was described in which the vegetative cells are indistinguishable from those of *Zygnema*. The reproductive structures, however, both zygospores and aplanospores, are entirely different from those of *Zygnema decussata* which it otherwise closely resembles. In addition to structural differences this alga has the characteristic secretion of pectic material and cellulose occupying the gametangia, or the sporangium, and adhering to the mature spore.

The zygospores and method of conjugation of *Zygnema spirale* described by Fritsch from South Africa are quite similar to those of *Debarya decussata* even to the tendency toward spiral twisting of the conjugated filaments. This form must therefore be transferred to *Debarya* if we accept the accumulation of pectic compounds and cellulose in the gametangia as the most important charactertisic of this genus, and are willing to concede that the chromatophores are of secondary importance. We must not overlook the fact that in the present genus *Mougeotia* there are not less than four forms of chromatophores (1) the single axile plate (most species), (2) the rod-shaped (*M. capucina*), (3). two parallel platelike chromatophores with the nucleus between (frequent in *M. robusta*), and (4) two axile

plates one in either half of the cell with the nucleus between (*M. punctata* mss.).

In 1895 Hallas described a peculiar conjugate under the name *Zygnema reticulata* which produced only aplanospores, whose vegetative cells in part resemble *Zygnema* and in part (according to her figures) *Mougeotia* with several pyrenoids in a chain. The aplanospores resemble those of *Debarya decussata* in having the sporogenous cells solid instead of empty as in *Zygnema*.

Recently Fritsch has figured and discussed a quite similar form from South Africa which reproduces by akinetes. Its vegetative cells in some cases resemble those of *Zygnema*, sometimes have four stellate chromatophores, and sometimes 2 or 4 greatly elongated chromatophores. Through the kindness of Miss E. Stephens of Capetown I have examined some of this material, and also a later collection of this same alga from another locality in which aplanospores were present. Some of the akinetes and aplanospores are shown in Figures 38 to 44. For the reasons stated above I believe this form is best classified as a *Debarya*.

Finally we must not overlook *Debarya africana* G. S. West in which the secretion from the gametes occurs only during the initial stages of conjugation. This is the only species in which it does not continue until the fusion of the gametes.

Clearly all the species here grouped under *Debarya* have (1) the common habit of secreting pectic material and cellulose during the formation and migration of the gametes, and (2) the whole of the contents of the conjugating cells enters into the formation of the zygospore. The first of these characteristics distinguishes this genus from both *Mougeotia* and *Zygnema*. The second separates it clearly from *Mougeotia*.

In several species of *Mougeotia*, for example *M. uberosperma*, *M. capucina*, and *M. tropica*, there are solid processes extending into the sporogenous cells from the zygospores, or the aplanospores. These are not formed, as in *Debarya* during the development and migration of the gametes, but immediately after the union of the gametes. Consequently these species differ from those here placed in *Debarya* in that the secretion of solid material follows conjugation and a part of the contents of the conjugating cells remains in the otherwise empty gametangia.

In view of all these facts the genus *Debarya* may be defined as follows:

DEBARYA Wittrock 1872.

Wittrock, V. B. 1872. Om Gotlands och Oelands Sotvattensalger Bih. Kgl. Swensk. Vet-Akad. Handl. Vol. 1, No. 1; Transeau, E. N. 1915. Notes on the Zygnemales. Ohio Jour. Sci., Vol. 16, p. 20.

Vegetative cells cylindrical or slightly constricted at the ends, varying from 1 to 16 diameters in length. The chromatophores vary from an axile plate with 2 or several pyrenoids, to an axile two lobed body with 2 pyrenoids, and finally to two radiate or elongate bodies each with one or several pyrenoids. Reproduction by zygospores *formed of the complete contents* of the gametangia and occupying the conjugating tube. The zygospores are not *separated from the gametangia by cross walls.* In the process of conjugation, as the gametes form and pass into the conjugating tube, a secretion of pectic material and cellulose occurs which either greatly thickens the gametangium walls or fills the gametangia. In Debarya more than in any of the genera of the *Zygnemaceæ* the spores vary in form and disposition of their cell walls. Aplanospores having walls similar to those of the zygospores occupy only a part of the sporogenous cell, the remainder being filled with pectic material and cellulose. Parthenospores and akinetes occur not infrequently in several of the species.

KEY TO THE SPECIES OF DEBARYA.

1. Forming aplanospores..11
1. Forming zygospores..2
2. Veg. cells usually with more than 2 pyrenoids in an axile chrom............3
2. Veg. cells with *only 2* pyrenoids in an axile chromatophore................ 7
2. Veg. cells with 2 or more *radiate chromatophores*..........................9
3. Diam. vegetative cells more than 18 microns..........................4
3. Diam. vegetative cells less than 18 microns..........................6
4. Spore wall smooth, spores extending beyond the tube...................5
4. Spore wall scrobiculate, spores contained in the tube.............3-D. lævis
5. Zygospores 50–56μ in diameter..............................1-D. africana
5. Zygospores 30–40μ in diamtere..............................2-D. immersa
6. Spores quadrangular, smooth..............................4-D. hardyi
6. Spores discoid with 3 prominent encircling ridges..........5-D. glyptosperma
6. Spores globose, or subglobose, pitted........................6-D. calospora
7. Spores compressed ovoid, scrobiculate....................7-D. americana
7. Spores quadrangular ovoid smooth..8
8. Diam. veg. cells 7.7–8.6μ..............................8-D. desmidioides
8. Diam. veg. cells 10–12μ..............................9-D. cruciata
9. Veg. cells with 2 radiate chromatophores..............................10
9. Veg. cells with 2–7 radiate chromatophores.................10-D. reticulata
10. Spores 30–36μ x 48–54μ..............................11-D. spiralis
10. Spores 24–30μ x 30–48μ..............................12-D. decussata
11. Diam. veg. cells 18–30μ, spores symmetrically ovoid........10-D. reticulata
11. Diam. veg. cells 16–20μ, spores unilaterally ovoid...........12-D. decussata
11. Diam. veg. cells 36–42μ, spores symmetrically ovoid.........13-D. pectinata

1. *D. africana* G. S. West. 1907. Jour. Linn. Soc. Bot Vol. 38, p. 104; pl. 5, fig. 3. Vegetative cells 23–26μ x 90–200μ chromatophores with 5–8 pyrenoids; zygospores globose-ovoid, 50–56μ in diameter,

filling the conjugating tube and extending nearly to the opposite thickened walls of the gametangia; spore wall smooth. Fig. 1. Nyassa, Africa.

This is the only species of the genus in which the gametangia do not become filled with pectic material and cellulose, as the gametes move into the tube during conjugation. There is a thickening of the walls, however, except at the center of each transverse wall.

2. *D. lævis* (Kuetz.) W. & G. S. West. 1897. Jour. Roy. Micros. Soc. p. 476; Mougeotia lævis Archer, Jour. Micros. Soc. 8: 65. 1869; Zygogonium læve Kuetzing, Spec. Alg. p. 447, 1849; G. M. Smith, Wis. Acad. Sci. Art. & Lett. 18 : 561, 1916; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, C-E, 1904.

Vegetative cells 20–26μ x 20–100μ, chromatophores with 2–4 pyrenoids; fertile cells elongated; zygospores filling the conjugating tube ellipsoid to ovoid 20–36μ x 42–50μ, median spore wall scrobiculate. Fig. 18. Europe; Wisconsin.

3. *D. immersa* W. West. 1902. Jour. Bot. 40 : 144; 41 : 58. Vegetative cells 20–24μ x 20–75μ, zygospores ovoid to subglobose, 30–40μ x 30–48μ, filling the tube and extending into the gametangia, median wall smooth. Not figured. India.

4. *D. calospora* (Palla) W. & G. S. West. 1898. Annals of Bot. 12 : 49; Jour. Bot. 38 : 289; Mougeotiopsis calospora Palla, Berichte Deutsch. Bot. Gesellsch. 12 : p. 228, 1894; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, B, 1904. Vegetative cells 11–18μ x 11–72μ, chromatophores with several pyrenoids more or less distinct; zygospores ovoid to globose, 18–26μ in diameter; median wall pitted, brown. Fig. 3. Europe.

5. *D. americana* Transeau. 1915. Ohio Jour. Sci. 16 : 18. Vegetative cells 9–12μ x 27–120μ, chromatophore an axile plate with two pyrenoids; fertile cells 10–14μ x 75–180μ; zygospores ovoid to quadrate ovoid 20–40μ x 30–40μ; parthenospores 15–20μ x 20–30μ, unilaterally ellipsoid with retuse ends, median spore wall minutely and irregularly verrucose, yellow-brown. Figs. 6, 7, 16 and 17. Ontario, Michigan.

6. *D. decussata* Transeau. 1915. Ohio Jour. Sci. 16 : 19. Vegetative cells 16–20μ x 24–50μ chromatophores as in *Zygnema* with two pyrenoids; zygospores ovoid to quadrate-ovoid, and irregular, 24–30μ x 30–48μ, angles rounded, retuse, or produced; aplanospores unilaterally ovoid, the plane of the convex side changes in successive cells, 17–25μ x 20–40μ parthenospores 15–20μ x 20–30μ, median wall in all the spores scobiculate; akinetes with smooth heavy walls, 18–20μ x 20–36μ. Fig. 28–33. Illinois, Michigan, Pennsylvania, Iowa, Ontario. In some collections only aplanospores occur, in others only zygospores. A majority of the collections contain both.

7. *D. hardyi* G. S. West. 1909. Jour. Linn. Soc. Bot. 39 : 51, Pl. 2; Algæ, Camb. Bot. Handbooks Vol. 1, p. 341, Fig. 213. 1916. Vegetative cells 6.4—7.5μ x 57–120μ, chromatophore an axile plate with 2–4 pyrenoids; zygospores quadrangular with straight or concave sides, angles retuse, 22.5–27μ. Figs. 2, 11, and 12. Spores possibly not mature. Australia.

8. *D. cruciata* Price. 1911. New Phytologist 10 : 87; 11 : 60. Vegetative cells 10–12μ x 30–60μ, chromatophore with 2 pyrenoids; conjugation between cells usually after dissociation of the filaments; zygospores quadrangular with concave or rarely straight sides, angles produced or slightly concave, 20–24μ x 28–32μ, median wall smooth. Fig. 13, 14 and 15. Spores possibly not mature. England.

9. *D. desmidioides* W. & G. S. West. 1903. Jour. Bot. 41 : 7, Pl. 446; G. S. West, Algæ Camb. Bot. Handbooks Vol. 1, p. 341, Fg. 213. 1916. Vegetative cells 7.7–8.6μ x 19–56μ constricted at the ends, chromatophore an axile plate with 2 pyrenoids; conjugation between free cells after dissociation of the filaments; zygospores 20–24μ x 22–30μ, median wall smooth. Figs. 8, 9, and 10. Spores possibly not mature. England.

10. *D. glyptosperma* (De Bary) Wittrock. 1872. K. Svenska Vet. Akad-Handl. 1 : 35; Conjug. p. 78, T 8. Fig. 20–25; Mougeotia glyptosperma De Bary, A., Conjugatæ p. 78, 1858; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, A. 1904.

Vegetative cells 9–16μ x 50–200μ, chromatophore an axile plate with several pyrenoids; zygospores lenticular to compressed ovoid, with median wall marked by three parallel ridges and polar projections, connected by radial lines; shorter axis 30–48μ, longer 42–72μ. Fig. 4. Europe; N. Zealand, New Hampshire, Massachusetts, Minnesota, Florida, Michigan.

Var. formosa Transeau. 1915. Ohio Jour. Sci. 16 : 18. Vegetative cells 7.5–9μ in diameter; zygospores 24–30μ x 30–42μ, median wall steel blue; otherwise like the type. California.

11. *D. reticulata* (Hallas) Transeau. 1915. Ohio Jour. Sci. 16 : 20; Zygnema reticulata Hallas. E., 20 : 1–16. 1895.

Vegetative cells 18–30μ x 35–100μ, with 2–7 chromatophores resembling those of *Zygnema*; zygospores unknown; sporogenous cells up to 240μ in length, inflated toward the middle, aplanospores subglobose to ellipsoid up to 35μ in diameter, median wall yellow, scrobiculate, and irregularly reticulate. Spores give rise to 1, 2, or 3 filaments on germination. Fig. 19–27. Europe.

12. *D. spiralis* (Fritsch) Comb. nov. Zygnema spiralis Fritsch, F. E., Annals South Africa Museum 9 : 564. 1918.

Vegetative cells 18–25μ x 40–130μ with two stellate chromatophores; zygospores quadrately ovoid formed in the greatly enlarged conjugating tube but extending into the gametangia, 48–54μ x 30–36μ. Mature spores lacking so that the character of the median wall is unknown. Figs. 34–37. South Africa.

13. *D. pectinata* (Fritsch) Comb. nov. Zygnema pectinatum, Fritsch, F. E., Roy. Soc. S. Africa 9 : 55. 1921.

Vegetative cells 36–42μ x 83–200μ with two stellate, or greatly elongated stellate chromatophores each with one pyrenoid, or more rarely 2 or 3 pyrenoids; zygospores unknown; akinetes swollen toward the middle to 80μ, with walls 6–8μ thick, sometimes obliquely ventricose alternating in successive cells; aplanospores 70–94μ x 100–128μ ellipsoid, or with polar thickenings, outer wall 4–8μ thick smooth, median wall irregularly tuberculate. Figs. 38–44. Kentani District, South Africa.

EXPLANATION OF FIGURES.

Plate I.

Fig. 1. *Debarya africana*, showing slight thickening of walls and pits in the centers of the cross walls. After G. S. West.

Figs. 2, 11, 12. *Debarya hardyi*, showing early stage of conjugation and immature zygospores. After G. S. West.

Fig. 3. *Debarya calospora*, vegetative cells and mature spores. After G. S. West.

Fig. 5. *Debarya glyptosperma*, mature spores. Drawn from material collected near Boston, Mass.

Figs. 6, 7, 16, 17. *Debarya americana*, mature spores and vegetative cell, from material collected by A. B. Klugh, Kingston, Ontario.

Figs. 8, 9, 10. *Debarya desmidiodes*, vegetative filament and spores. After G. S. West.

Figs. 13, 14, 15. *Debarya cruciata*, conjugating cells and immature zygospores. After Price.

Fig. 18. *Debarya lævis*, vegetative cell and mature zygospores. After G. S. West.

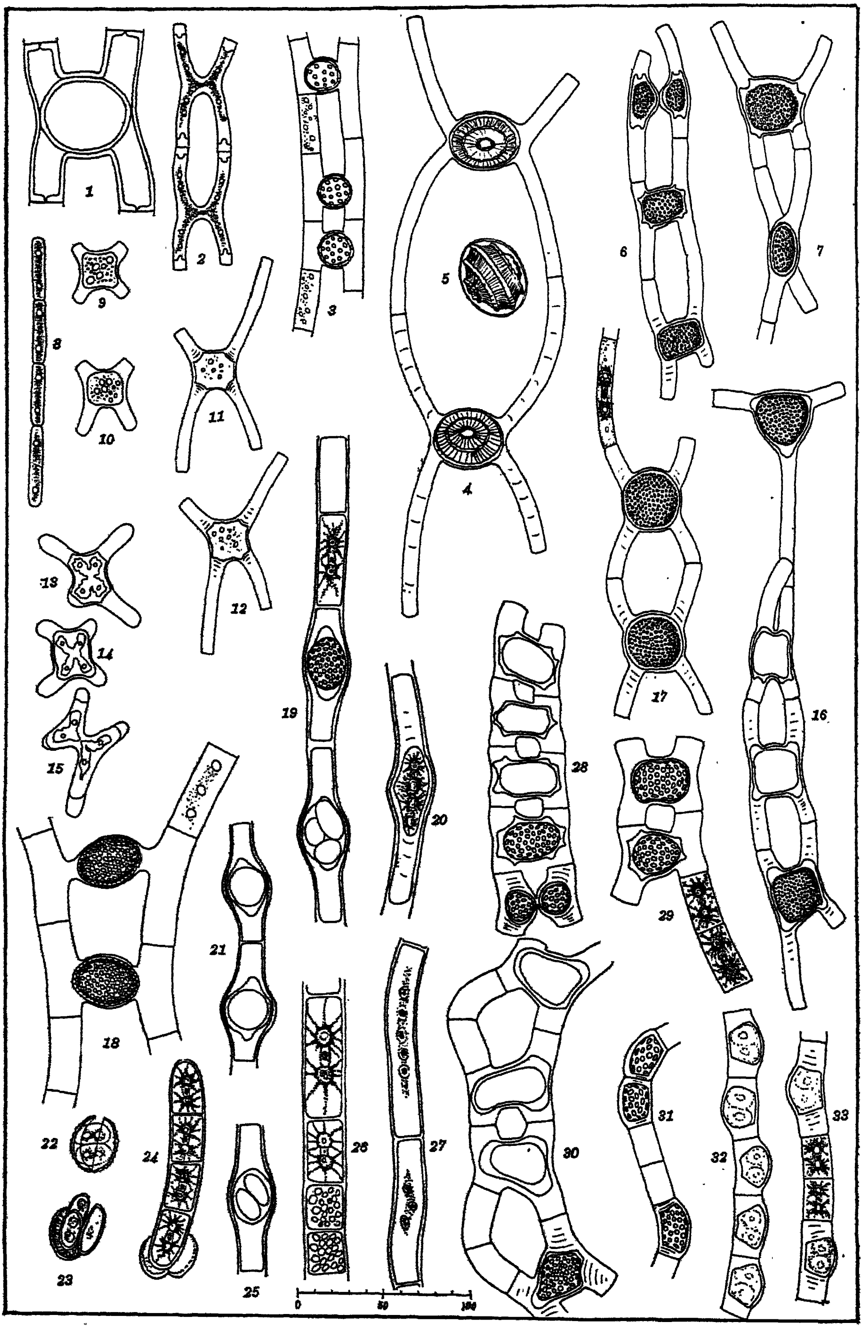
Figs. 19–27. *Debarya reticulata*, vegetative cells, aplanospores, akinete, (Fig. 20), and germinating aplanospores. After Hallas.

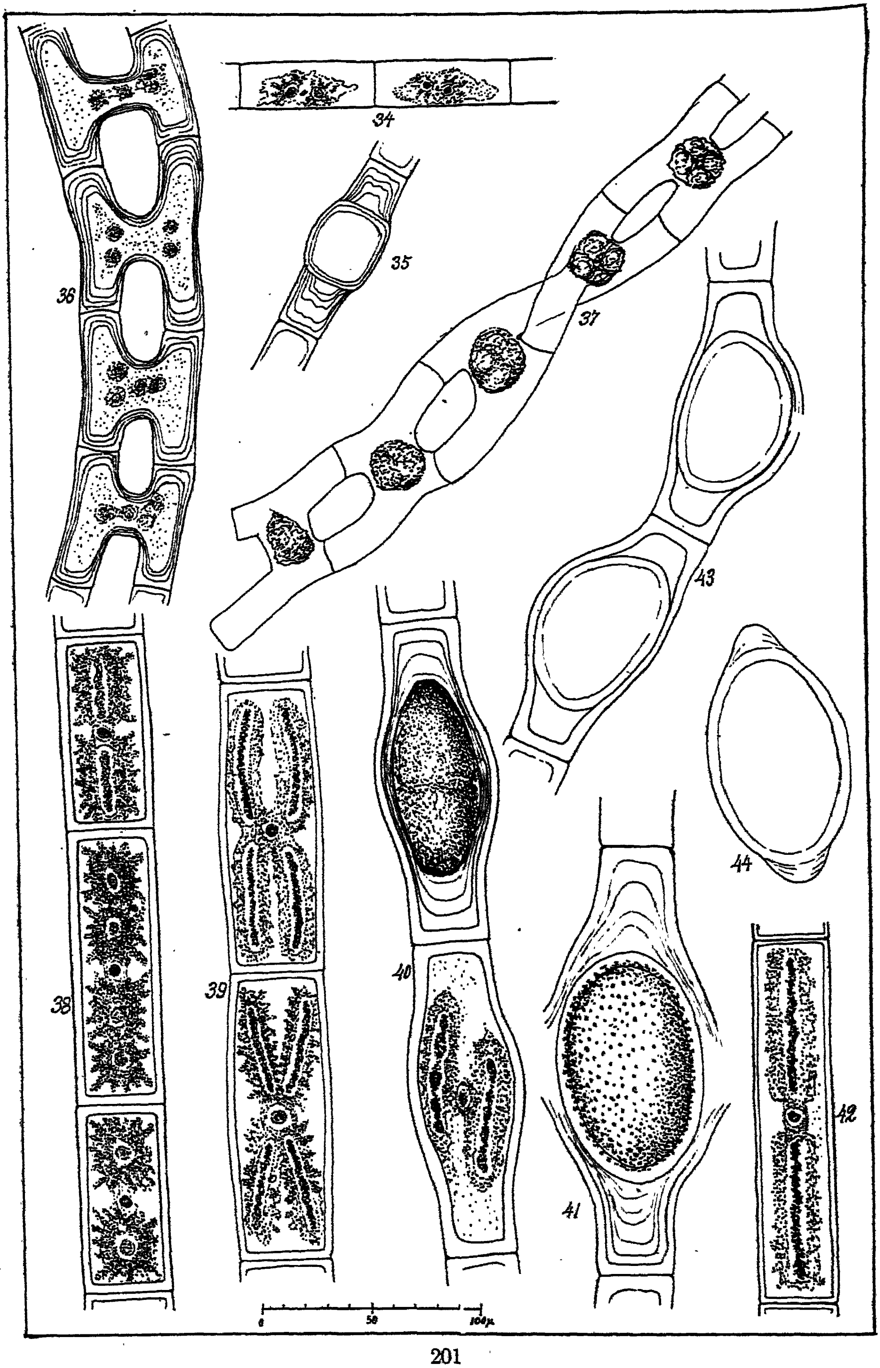
Figs. 28–33. *Debarya decussata*, vegetative cells, zygospores, parthenospores aplanospores (Fig. 31), and akinetes (Figs. 32–33). Drawn from material collected at Charleston, Illinois.

Plate II.

Figs. 34–36. *Debarya spiralis*, vegetative cells, conjugating cells, immature zygospores (Fig. 37), zygospore side view (Fig. 35). After F. E. Fritsch.

Figs. 38–44. *Debarya pectinata*, vegetative cells showing variety of chromatophores, akinete (Fig. 40), and aplanospores probably not completely matured. Drawn from material collected by H. A. Pocock, Oct. 23, 1923, Cedar Mountains, Clan William, in shallow stream. For other figures see paper by F. E. Fritsch.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
0
50
100


34
35
36
37
38
39
40
41
42
43
44
0
50
100μ

Date of Publication: July 21, 1925.

THE OHIO JOURNAL OF SCIENCE

VOL. XXV SEPTEMBER, 1925 No. 5

DIGESTIVE ENZYMES OF AN INSECT.*

H. S. SWINGLE,
Department of Zoology and Entomology, Ohio State University.

INTRODUCTION.

Digestion is a phase of Insect Physiology on which surprisingly little research has been done, considering the economic importance of the food of insects and the fact that our most important control measures involve the action of digestive juices on poisons taken into the digestive tract.

The cockroach (*Blatta orientalis* Linn.) was chosen for this study as it was available in quantities, and represented a generalized type of insect. Methods found of value in its study can be readily used upon such specialized types as the wood-, meat-, starch-, and sugar-feeders.

Our little knowledge of this problem is due to the investigations of F. Plateau (1), carried on about 1875. He came to the following conclusions:

1. The saliva of the cockroach changes starch to glucose, and is either neutral or alkaline. The reduction of copper in Barreswil's solution, a reagent similar to Fehling's solution, was taken as an indication of the presence of glucose.

2. The fore gut does not secrete digestive fluids. The contents are neutral, alkaline, or acid, depending on the food eaten.

3. The gastric cœca secrete a fluid which digests proteins. In his paper, "Les phenomenes de la digestion chez la Blatte americaine," he reports the fluid alkaline. Miall and Denny (2), cite him as having found it acid.

4. In the mid gut proteins are digested and fats emulsified (1). Miall and Denny (2) report Plateau in 1886 as having believed that no digestion takes place there.

* Contribution No. 85 from the Department of Zoology and Entomology, Ohio State University.

In the first series of tests in the present work, tissue suspensions were used, while in the second series the canal contents were tested directly. Macrochemical enzyme tests were used in the first case, and microchemical methods were developed for use in the second series.

I wish to acknowledge my great indebtedness to Drs. J. F. Lyman, C. H. Kennedy and R. C. Osburn, Ohio State University, for criticisms and suggestions.

Macrochemical Tissue-Suspension Method.

Tissue suspensions of the various organs were prepared and the presence of the enzymes tested for. An equal number of checks and tests were run for each experiment. The checks were made up in exactly the same manner as the tests, except that the tissue suspensions were first boiled to destroy the enzymes.

Preparation of the Tissue-Suspensions.

Insects, freshly killed with chloroform, were dissected under distilled water. The digestive tracts were removed, split open, and the contents thoroughly washed out, using distilled water. Each tract was then divided into the following four parts: fore gut, gastric cœca, mid gut, and hind gut. The salivary glands were also removed, and each of the tissues placed in a separate flask containing 30 cc. of pure glycerin.

After these tissues had been secured from 100 roaches, the glycerin-whole tissue suspensions were poured into mortars and the tissues reduced to a pulp with a pestle. The resulting suspensions were then replaced in the flasks and were ready for use. They will keep indefinitely.

AMYLASE.

This enzyme hydrolyzes starch, forming maltose.

Davis' Potato Starch Substrate (6): Add 10g potato starch to 250 cc. water. Boil with constant stirring till opalescent. Transfer to a 2 liter flask containing 500 cc. boiling water. Boil under reflux condenser for two hours. Cool, and make up to 1 liter. Preserve with 2% toluene.

Procedure: To 5 cc. of the above solution, add 1 cc. tissue suspension and .5 cc. toluene.

Iodine Test: Test every two minutes with iodine solution for the presence of starch. Record time taken to reach achromic point.

Fehling's test: After 48 hours, the above solution was tested for the presence of reducing sugars with Fehling's solution.

Results: Salivary gland...............heavy precipitate.
Other tissues and checks.......no precipitate.

Conclusion: Amylase is present only in the salivary gland.

MALTASE.

This enzyme hydrolyzes maltose, forming glucose.

Procedure: 35 cc. of 1% maltose solution plus 1 cc. tissue suspension plus 2 cc. toluene. Incubate 24 hours at room temperature.

Barfoed's test for monosaccharides:

Salivary gland	no precipitate.
Fore gut	slight "
Gastric cœca	heavy "
Mid gut	heavy "
Hind gut	no "
5 checks	no "

Saccharimeter Readings (Bates' type instrument):

Tissue	18 hours	22 hours
Salivary glands	+6.1	+6.1
Check	+6.1	+6.1
Fore gut	+5.5	+5.4
Check	+6.1	+6.1
Gastric cœca	+4.5	+4.1
Check	+6.1	+6.1
Mid gut	+5.5	+5.0
Check	+6.1	+6.1
Hind gut	+6.2	+6.2
Check	+6.2	+6.2

Conclusion: Maltase is present in the foregut, gastric cœca, and mid gut.

INVERTASE.

This enzyme hydrolyzes sucrose, forming fructose and glucose.

Procedure: 5 cc. of 1% sucrose solution + 1 cc. tissue suspension + .5 cc. toluene. Incubate 18–24 hours at room temperature.

Fehling's test for reducing sugars:

Salivary gland	no precipitate
Foregut	slight "
Gastric cœca	heavy "
Mid gut	heavy "
Hind gut	no "
5 checks	no "

Conclusion: Invertase occurs in the fore gut, gastric cœca, and mid gut.

Results: Salivary gland, 20 minutes. Other tissues and checks showed no digestion in 48 hours.

LACTASE.

This enzyme hydrolyzes lactose, forming glucose and galactose.

Procedure: 5 cc. of 1% lactose solution + 2 cc. tissue suspension+2 cc. toluene. Incubate 24 hours at room temperature.

Saccharimeter Readings (Bates' Type Instrument):

Salivary gland	+3.00
Check	+3.00
Fore gut	+3.00
Check	+3.00
Gastric cœca	+3.00
Check	+3.00
Mid gut	+3.00
Check	+3.00
Hind gut	+3.00
Check	+3.00

Conclusion: Lactase is not present.

LIPASE.

This enzyme splits fats into fatty acids and glycerol.

Bloor-Raper (6, 9) *Neutral Olive Oil Emulsion:*

To 4 g. of casein, on a water bath, add water till a thin paste is formed Add two drops of phenolphthalein and enough N/1 NaOH to give a permanent pink tinge. Stir in 8 cc. olive oil till the globules disappear. Cool, dilute to a 4% emulsion.

Procedure: 5 cc. emulsion+2 cc. tissue suspension +.5 cc. toluene. Incubate 18 hours at room temperature. Titrate the freed acid with N/20 NaOH. Phenolphthalein indicator.

Tissue	Cc. N/20 Acid present
Salivary gland	.3cc.
Check	.3cc.
Fore gut	.9cc.
Check	.3cc.
Gastric cœca	1.3cc.
Check	.4cc.
Mid gut	1.0cc.
Check	.3cc.
Hind gut	.4cc.
Check	.4cc.

This experiment was repeated with the same results, using a 2% Acacia-Olive Oil emulsion (5) with thymol as a preservative.

Conclusion: Lipase is present in the fore gut, gastric cœca, and mid gut.

PEPSIN.

This enzyme, in an acid solution, breaks complex proteins down into peptones. Fibrin, at the suggestion of Dr. Lyman, was dyed in a 1% aqueous solution of amaranth red for 15 minutes. All surplus stain was then removed by thoroughly washing with water whose acidity was adjusted to pH=3 with HCL. This gave a red fibrin whose color would not come out in an acid solution.

Even the slightest digestion of the fibrin is then made apparent by a noticeable red color in the digested fluid.

Procedure: Adjust the tissue suspensions to an acidity whose pH=2 with HCL. 2 cc. tissue suspensions +colored fibrin+.5 cc. toluene.

Incubate 96 hours at room temperature.

No digestion was apparent.

Conclusion: Pepsin is not present in this insect.

TRYPSIN.

This enzyme, in an alkaline solution, breaks complex proteins down into peptones.

Procedure: The tissue suspensions were adjusted to an acidity whose pH=7.4 with Na_2 CO_3.

2 cc. tissue suspension +fibrin +.5 cc. toluene.

Gastric cœca..................digestion complete in 24 hours.
Mid gut.....................digestion complete in 48 hours.
Other tissues and checks......no digestion in 96 hours.

Conclusion: Trypsin is present in the gastric cœca and mid gut.

EREPSIN.

This enzyme splits peptones into amino-acids.

Salaskin's Phosphotungstic Acid Method (4, 3): To 25 cc. of a 1% peptone solution, whose acidity was adjusted to pH=7.6, add 2 cc. enzyme solution and 2 cc. toluene. Incubate at room temperature for 48 hours. Add phosphotungstic acid till no further precipitation occurs. Filter, and determine the nitrogen content of the precipitate by the Kjeldahl method. The presence of erepsin is indicated by a decrease in the N-content of the precipitate from that in the checks.

Tissue	g. Peptone-N (Precipitate)	Digested Peptone N.
Salivary gland	.01036g	0.0000g
Check	.01036g	0.0000g
Fore gut	.01050g	0.0000g
Check	.01050g	0.0000g
Gastric cœca	.00196g	0.0854g
Check	.01050g	0.0000g
Mid gut	.00826g	0.0124g
Check	.01050g	0.0000g
Hind gut	.01050g	0.0000g
Check	.01050g	0.0000g

Conclusion: Erepsin is present in the gastric cœca and mid gut.

Summary of Macrochemical Tissue Suspension Method.

Enzyme	Where Found
Amylase	Salivary gland.
Maltase	Fore gut, gastric cœca, mid gut.
Invertase	Fore gut, gastric cœca, mid gut.
Lactase	Absent.
Lipase	Fore gut, gastric cœca, mid gut.
Pepsin	Absent.
Trypsin	Gastric cœca, mid gut.
Erepsin	Gastric cœca, mid gut.

Microchemical Method of Enzyme Analysis.

The tissue suspension method used above is open to the criticism that it merely demonstrates the presence of enzymes in the tissues. It does not prove that these enzymes are secreted into the digestive canal nor that they function in the portion of the canal where they are secreted. Therefore, to check the above results, the contents of the various parts of the canal were collected and tested for the presence of those enzymes which had been found by the tissue suspension method.

In this investigation tests were sought which would be of use with smaller amounts of material, since the macrochemical tissue suspension method used above can find only limited application due to the large numbers of insects required for analysis.

By the following microchemical methods, the complete enzyme analysis of the canal contents can be carried out, with definite results, using the material obtained from two roaches. These tests can also be used with little or no change in tissue suspension analyses, although they were not so used in this investigation.

General Procedure.

The alimentary canals were obtained from freshly killed roaches, divided into the fore, mid and hind guts, and the contents removed. These materials were then diluted with equal volumes of distilled water, and the acidity regulated as desired. They were then ready for use.

The incubations were carried on at room temperature in micro-tubes, about 1¼ inches long, made from ¼-inch glass tubing.

The checks were made up with boiled enzyme solutions.

To each check and test, in the micro-tubes, was added enough toluene to cover the surface of the liquid. This prevents the action of microorganisms.

AMYLASE.

Starch-Iodine Test: To a dilute starch paste, add sufficient I-KI solution to give a dark blue color. Place in micro tubes, add a small amount of the enzyme solution, and cover with toluene. Incubate 48 hours. When the starch is digested, the solution will be colorless. Then, to the colorless tubes add several drops of I-KI solution. If no blue color develops, digestion is complete. This last check should be made to make sure that the loss of color was not due to the absorption of iodine by fats in the enzyme solution.

Fluckiger test for reducing sugars (12:) Incubate starch paste+enzyme solution+toluene for 48 hours. Add one drop of the resulting solution to a drop of Fluckiger's reagent on a slide. Add a cover glass and heat gently. A red precipitate of copper indicates the presence of reducing sugars.

Fluckiger's reagent: Mix a drop of 20% NaOH with an equal amount of powdered copper tartrate on a slide till the copper is dissolved. The reagent is then ready for use.

Results: Amylase was found in the fore gut, mid gut and hind gut.

MALTASE.

Procedure: 5% Maltose solution+enzyme solution+toluene. Incubate 72 hours in micro tubes.

Phenylhydrazine-Osazone Test (10): Mix one drop of Phenylhydrazine-HCL (1-10 glycerin) and one drop of Sodium acetate (1-10 in glycerin) on a slide. Add one drop of the incubated solution. Add the cover glass.

Heat on the water bath for 15 minutes. The glucose osazone will appear within an hour on cooling. Maltose osazones appear 3–4 days later.

Results: Maltase was present in the fore and mid guts.

INVERTASE.

Procedure: 5% sucrose solution+enzyme solution+toluene. Incubate 48–72 hours.

Phenylhydrazine-Osazone test: (10): This test is given above. Heat 15 minutes on the boiling water bath. Fructose osazones appear immediately; Glucose osazones within an hour on cooling.

Fluckiger test for reducing sugars: Fructose reduces the copper instantly in the cold. Glucose reduces it on warming.

Methyl-phenylhydrazine-Osazone test: Mix 1 drop of Methyl-phenylhydrazine acetate (1-10) in glycerin and 1 drop of sodium acetate (1-10 in 50% glycerin). Add sugar solution. Gives osazone with fructose on heating gently for 7–8 minutes.

Results: Invertase was present in the fore gut, mid gut and hind gut.

LACTASE.

Procedure: 5% Lactose solution+enzyme solution+toluene. Incubate in micro tubes 48–72 hours.

Phenyl-hydrazine-Osazone test (12): This test is described above. Glucose osazones are taken as an indication of the presence of lactase.

Results: No lactase was present.

LIPASE.

B. T. B.-Tristearin test: Wash commercial tristearin repeatedly with 70% alcohol to rid of free fatty acids. Melt, and add sufficient KOH to give it an acidity whose pH = 7.2. Pour into the micro tubes to a depth of ½ inch. Allow to harden.

Add several drops of Brom Thymol Blue to the enzyme solution and sufficient Na_2CO_3 to give it a blue color (pH=7.2).

Add the blue enzyme solution to the tristearate in the micro tubes, cover with toluene, and incubate 48–96 hours.

As the fat is digested a green to yellow zone forms at the junction of the fat and liquid, and eventually the entire solution becomes greenish yellow to yellow due to the liberation of fatty acids.

B. T. B.-Emulsion test: Add several drops of Brom Thymol Blue to the emulsions prepared as directed under the tissue suspension method for lipase. Add sufficient NaOH to give a blue color. Prepare the enzyme solution as in the above test and add it to the blue emulsion in micro tubes. Incubate 48–96 hours.

The change from blue to greenish yellow or yellow indicates the presence of lipase.

Results: Lipase was present in the fore gut and mid gut.

PEPSIN.

Colored Fibrin method: Color fibrin with Amaranth red as directed under the tissue suspension method for Pepsin. Place a small piece of the red fibrin in the bottom of a micro tube. Add the enzyme solution whose acidity is adjusted to pH=2 with HCL. Cover with toluene. Incubate 48–96 hours. Digestion is indicated by a strong red color in the solution.

Results: Pepsin was not present.

TRYPSIN.

Colored Fibrin Method: Stain fibrin 15–30 minutes in Anilin Blue. Wash with alkaline water (pH=7.6) till all surplus stain is removed. Place a small piece of the blue fibrin in the bottom of the micro tubes and add the enzyme solution whose acidity is adjusted to pH=7.6 with Na_2CO_3. Cover with toluene. Incubate 48–96 hours. Digestion is indicated by a strong blue color in the solution.

Results: Trypsin was present in the fore gut, mid gut, and hind gut.

EREPSIN.

Modified Sorensen Method: Solution A: Add several drops of Brom Thymol Blue to a 4% peptone solution, and then sufficient KOH to give a blue color (pH=7.6).

Solution B: Add several drops of Brom Thymol Blue to 40% Formalin and then sufficient 2% KOH to give a blue color. Add additional 2% KOH a drop at a time till when 1 cc. of this solution is mixed with 2 cc. of solution A, the resulting color remains blue.

Procedure: To solution A in the micro tubes, add the enzymes solution and toluene. Incubate 48–96 hours.

Then add a volume of solution B equal to one-half the volume of A in the micro tubes.

Digestion by erepsin with the liberation of amino acids is indicated by a greenish yellow to yellow color on the addition of solution B.

Results: Erepsin is present in the fore gut, mid gut, and hind gut.

Summary of Microchemical Analysis.

Enzyme	Found in contents of:
Amylase	Fore gut, mid gut, hind gut.
Maltase	Fore gut, mid gut.
Invertase	Fore gut, mid gut, hind gut.
Lactase	Absent.
Lipase	Fore gut, mid gut.
Pepsin	Absent.
Trypsin	Fore gut, mid gut, hind gut.
Erepsin	Fore gut, mid gut, hind gut.

General Conclusions.

In the tissue suspension experiments, no maltase could be detected in the salivary glands. Plateau states that the saliva can change starch to glucose, in which case maltase would necessarily be present. However, he took the positive Barreswil's test as an indication of the presence of glucose. This test is given by any reducing sugar, since Barreswil's and Fehling's solutions are practically identical. It was, without doubt, maltose and not glucose which gave the positive test.

The gastric secretion must be alkaline or at least only slightly acid since trypsin is the only enzyme present splitting complex proteins.

From the tissue tests, it appears that three enzymes, namely, maltase, invertase, and lipase are present in the cells of the fore gut. Plateau states that no enzymes are secreted by the fore gut, but that the digestive fluid from the gastric cœca rises into that portion of the gut and that digestion takes place there. It is also generally accepted, from morphological studies, that the fore gut does not secrete digestive juices. In these experiments, the contents of the fore gut were washed out thoroughly with distilled water. Any enzymes found there then, must be in the cells or the chitinous lining of the tract.

These enzymes therefore, must either have been formed by the cells of the fore gut, or absorbed by them from the digestive cavity. This cannot be settled by the evidence at hand. However, in the latter case, it would be expected that all the digestive enzymes found by the microchemical analysis in the fore gut, should also be found in the tissue preparation. This of course, is not necessarily so. Regardless of the origin of the

enzymes, we at least know that they are present in the fore gut and that most of the digestion takes place there.

Plateau's contention that the secretion from the gastric cœca rises into the fore gut is borne out by the fact that enzymes were found in the fore gut contents which could have been secreted only by the gastric cœca or the mid gut. As the mid gut secretes only small amounts, the gastric cœca would appear as the logical source of these enzymes.

The salivary glands and the gastric cœca are the most important sources of the digestive enzymes. The mid gut produces the same enzymes as the gastric cœca, but less abundantly. Its main function appears to be absorption rather than secretion.

The hind gut does not secrete digestive enzymes. Its main function appears to be the elimination of waste. Enzymes may be found in the contents of that portion nearest the mid gut, but are not demonstrable near the rectum. From this, it would appear that the enzymes are either reabsorbed or destroyed in the hind gut.

BIBLIOGRAPHY.

1. F. Plateau. 1876.
Les Phenomenes de la digestion chez la Blatte americaine.
2. Miall and Denny. 1886.
The Cockroach. London, Lovell Reeve & Co.
3. J. Wohlgemuth. 1913.
Grundriss der Fermentmethoden. Berlin: Verlag von Julius Springer.
4. S. Salaskin. 1902.
Uber das Vorkommen des Albumosen resp. Pepton spaltenden Fermentes in reinem Darmsafte von Hunden. Zeitschr. f. physiol. Chem. 35, 419, 1902.
5. Bergheim. 1923.
Am. Jour. Physiol. 66, 297–301, 1923.
6. A. R. Davis. 1915.
Enzyme Action in Marine Algae. Washington Univ. Ser. V, No. 24.
7. M. Bodansky and W. C. Rose. 1922.
Comparative Studies of Enzymes. 1. The DigestiveEnzymes of Coelenterates. Am. Jour. Physiol. Vol. 62, No. 3, pp. 473–482.
8. W. R. Bloor. 1914.
A Method for the Determination of fat in small amounts of blood. Jour. Biol. Chem. 17 : 377–384. 1914.
9. H. S. Raper. 1913.
Experiments Bearing on the Function of the Liver in the Metabolism of Fats. Jour. Biol. Chem. 14 : 117. 1913.
10. S. H. Eckerson.
Microchemical Outline.
11. H. Molisch. 1913.
Mikrochemie der Pflanze. Jena: Verlag von Gustav Fischer.
12. O. Tunmann. 1913.
Pflanzenmikrochemie. Berlin: Verlag von Gebruder Borntraeger.

PRINCIPLES OF PLANT TAXONOMY II.*

JOHN H. SCHAFFNER
Ohio State University

THE EVOLUTION OF THE FLOWER.

The views and deductions presented below, as to the general nature of floral evolution, represent the results of twenty-five years of intensive study of the flower from the phylogenetic standpoint and are presented, for the most part, as the settled convictions of the writer, with the confidence that any one examining the evidence carefully will come to essentially the same conclusions. One of the striking differences between the sporophytes of the Bryophytes and those of the lowest types of Pteridophytes is the very determinate growth of the former and the indeterminate, repetitive growth of the latter. Ideal examples of such primitive, indeterminate systems are seen in *Lycopodium lucidulum*, *Botrychium virginianum*, and the typical tree ferns with a single, long-lived terminal bud. In the forward evolution of the more complex types of higher plants, some of the axes become determinate while other buds continue the indeterminate development. Determinate are axes of several types: first, a mere vegetative, special differentiation which ends in the permanent stopping of the growth of the bud, as in the small branches of *Lycopodium obscurum* and the sterile shoots and branches of most of the species of Equisetum; second, the development of a special organ from the bud, as a thorn or a tendril which differentiation usually brings about a permanent cessation of growth; third, the development of an abscission layer by which the terminal bud of the axis, or an entire branch is self-pruned; and fourth, the development of determinate, sporophyll-bearing axes or flowers in which the bud usually stops growing, much as in the first type, without any very special differentiation outside of the fact of sporophyll development. It is this last type of development that is the subject of the present paper.

In the flowerless, vascular plants, as for example, *Lycopodium lucidulum*, or *Osmunda cinnamomea*, the axis is continued

* Papers from the Dehartment of Botony, The Ohio State University, No. 155.

indefinitely, giving rise to alternate zones of foliage leaves and sporophylls which in temperate regions usually have a rather definite relation to the seasons. From such indeterminate axes flowers evolve. A flower may be defined in the briefest way as a determinate sporophyll-bearing shoot, or a modification of such a shoot. Or in simpler words, a flower is a modified sporophyll-bearing shoot which has ceased growing permanently. It is important that this definition be thoroughly assimilated by those who wish to understand the evolution and phyletic classification of the higher plants.

A flower then has three fundamental characteristics, and these three peculiarities are present in the flowers of all living species. First, the most fundamental fact is the stopping of growth of the floral axis. If the flower is of a primitive type, i. e., not far removed from the indeterminate type of sporophyll-bearing axes, proliferation is a rather common occurrence. This proliferation is to be regarded as an atavistic or reversion phenomenon. The functional activity, through one cause or another, is not completely checked in cells of the terminal bud which continues a vegetative growth and sometimes a second or even third zone of sporophylls. Species in which proliferation can frequently be seen are *Equisetum fluviatile, Lycopodium obscurum, L. complanatum, Larix larix*, and among the higher types certain species of Rosa. The second characteristic of the flower, which is almost a consequence of the first, is the crowding of the sporophylls on the floral axis. This becomes especially striking in the higher species where internodes are developed between the foliage leaves or leaf whorls. The third characteristic is the specialization of the sporophylls as compared with the foliage leaves. This specialization of the sporophylls is not confined to flowers, but is often also very pronounced in the more highly specialized flowerless plants like *Osmunda cinnamomea* and *Onoclea sensibilis.*

Since the flower arises through a determinate growth of an axis in very primitive species, it follows that the most primitive flowers are solitary or isolated on the ends of leafy shoots and there is no abrupt transition between the shape and general character of the foliage leaves on the one hand and the sporophylls on the other. There is no flower cluster. Such conditions are seen in *Lycopodium annotinum*, the lower types of Equisetum, Araucaria, the carpellate cone of *Sequoia wash-*

ingtoniana, and in some higher types of flowers as *Magnolia foetida*. In Magnolia, although the flower, outside of its possession of a very primitive kind of perianth, represents a low type of strobilus, there is a distinct development of the peduncle which must be regarded as a considerable advancement. This development of a peduncle is probably partly due to the presence of a prominent internodal system. In primitive flowers, therefore, because of their position at the end of a free branch the symmetry is spiral and radially actinomorphic. In the main line of evolution, which leads to the living seed plants, the stem is a monopodial system, and sooner or later the floral expression is shifted from the terminal bud to axillary or lateral buds; or both terminal and axillary buds of the same branching system may become sporophyll-producing axes.

The lowest flowers, as would naturally follow in an evolution from indeterminate to determinate axes, usually have a large number of parts before the growth is discontinued. The process by which cessation of growth is brought about is developed very gradually when sporophyll production begins. Low types of flowers are, therefore, characterized by having large numbers of parts and these numbers are always indefinite. Such low types of flowers are to be seen in *Lycopodium annotinum*, *L. alopecuroides*, *Equisetum praealtum*, *Selaginella rupestris*, *Dioon edule*, *Araucaria imbricata*, *Agathis australis*, *Magnolia foetida*, *Myosurus minimus*, *Anemone cylindrica*, and *Rubus occidentalis*. In low types of flowers, when the species has a vegetative internodal system, there is sometimes a tendency to produce an internode between the andrecium and gynecium. Prominent internodal developments of this kind are found in *Michelia fuscata* and *Geum rivale*. The development of such internodes is probably due to the fact that the growing bud of the floral axis reverses its sex from the male to the female condition. In doing this it necessarily passes through a neutral state which produces the physiological condition of the vegetative shoot, and since in such a primitive flower the factors of determination act very slowly and slightly, it appears that under the conditions, the internode-producing factors are thrown into activity and a short internode is the result. But such flower-internodes are rare and apparently in most cases the factors of determination which are shortening the axis prevent any internodal growth even when the cells are passing through the neutral condition from maleness to femaleness.

The lower type of flower is usually called a strobilus or cone as distinguished from a higher "flower," but the transition is a very gradual one and the higher flowers have nothing characteristic in the floral development itself. One can only make clear distinctions on characters developed on the floral leaves themselves or other detailed structures. What are usually called "flowers" in our manuals and textbooks differ in the possession of closed megasporophylls or carpels with stigmas at their tips. But as stated, this is not a difference in flowers, but a difference in sporophylls. One can find just as fundamental differences in the various types of strobili. And even some of the flowerless plants have enclosed sporangia, like in the completely closed up leaflets forming the sporocarps of Marsilea or the partially enclosed leaflets of the sporophylls of Onoclea. The popular notion of a flower is something very showy, especially with bright colors. From such a viewpoint the cones of Norway Spruce, *Picea abies*, and the Longleaf Pine, *Pinus palustris*, become flowers, while ragweeds (Ambrosia) *Amaranthus blitoides*, and *Populus tremuloides* have no flowers.

Flowers were evolved in a number of entirely independent lines. In the Lepidophyta, there is still living a rather complete series of species ranging from the flowerless condition to a well specialized strobilus and even an inflorescence. In the Ptenophyta or fern phylum, no floral development seems to have appeared until the higher phyla, developed from this mother phylum, were evolved with heterospory and seeds. In the Calamophyta, represented among living plants by the genus, Equisetum, the determinate floral axis is also developed in the homosporous condition. Among seed plants, the lower Cycadophyta were also flowerless and this condition continues here and there even to the highest members of the phylum. The greater part of this fern-like phylum is fossil, but in the living genus Cycas, which is diecious, flowers appear only in connection with the male state. The carpellate plants, with the female sexual state, produce their megasporophylls on indeterminate axes in zones alternating with foliage leaves as in the ferns. In the Class Ginkgoæ, the one remaining species, *Ginkgo biloba*, also diecious, produces both its stamens and carpels on the indeterminate dwarf branches, alternating with zones of foliage leaves, thus showing the primitive flowerless condition. Some have interpreted the carpels and stamens

of Ginkgo as highly specialized strobili, but such a view seems entirely impossible. The carpels plainly show the vestige of a leaf blade, and the degree of evolutionary advancement does not agree at all with such a supposition. The carpel of Ginkgo is but the extreme of a reduction series as indicated in passing from Cycas revoluta through a succession of forms to Zamia. The stamen can easily be homologized with the stamen of the Bennettitales.

Among seed plants, therefore, many of the lowest species probably had no determinate axes, but a single indeterminate, terminal bud as in various tree ferns. In *Cycas revoluta*, the carpellate plant has no determinate buds, but the staminate plant produces determinate, staminate cones. In the higher Cycadaceæ both staminate and carpellate plants have indeterminate vegetative axes and determinate floral axes. Ginkgo is the highest species which has only indeterminate buds, since both the long and dwarf branches grow indefinitely. In Pinus the evolution of buds has developed as far in complexity as the higher lycopods and horsetails, having terminal indeterminate, vegetative buds on the long branches, determinate buds on the self-pruned dwarf branches, and determinate buds in the staminate and carpellate cones.

The living Strobilophyta all have flowers, ranging from very primitive types of strobili in Araucaria, Agathis, and Cunninghamia to such extreme reductions as the modified cones of Juniperus and Taxus, and the very highly specialized inflorescences of the Gneteæ or joint-firs.

The Anthophyta, as the name indicates, are also all flowering plants of the very highest types, the lowest representatives having flowers of indefinite numbers, and being spirally actinomorphic, like Magnolia and Echinodorus, not very far removed from the typical strobilus. Since the fossil record of the ancestors of the Anthophyta is practically a blank up to the present time, there is no way of telling at what stage of the evolution of the phylum flowers probably appeared. But the phylum appears to be an entirely independent line whose nearest known relatives are the flowerless, eusporangiate ferns. Taking the evidence from living representatives, it is clear that in some groups the flower condition was attained far down the scale in the homosporous stage of evolution, while in others the indeterminate axis was retained far beyond the heterosporous stage, even to a high degree of seed development.

The flowers of living plants can, therefore, be classified as: 1st, homosporous flowers, the most primitive type of strobili, as in Lycopodium, Equisetum, etc., 2nd, heterosporous, seedless flowers, as in Selaginella; 3d, heterosporous seed-bearing flowers with open carpels and without or with a very primitive development of the perianth, as in Cycadeæ, Coniferæ, and Gneteæ; 4th, heterosporous, seed-bearing flowers with closed carpels and with a well-developed perianth or vestige of one, or in a few cases with the perianth entirely obliterated.

The development of a perianth (sterilized modified sporophylls) is met with first as a rather definite structure in the highest Equisetaceæ, like Equisetum arvense, which has a small, calyx-like cup at the base of the cone, above the long peduncle. In some of the pines the carpellate cone shows two well-marked zones when young, as in *Pinus laricio* and other species. The lower zone of carpels remains small and does not develop seeds, while the upper carpels enlarge and the ovules develop into seeds. The Anthophyta all have bisporangiate flowers originally, with the stamens below, and the typical perianth must, therefore, be regarded as coming from modified, sterilized stamens or microporophylls. The lowest Cycadeæ (Bennettitales) also had bisporangiate flowers with the stamens below, but our living Coniferæ all passed promptly to the monosporangiate condition before the state of floral advancement was attained when a perianth might appear. We can safely say, then, that among living plants, the Anthophyta are the only ones which have a true perianth derived from the andrecium, and all living species at least have such flowers or flowers evolved from such a type.

The cause of the sterilization of the base of the strobilus or of the more highly developed Angiosperm flower is obscure. It has occurred to the writer that the cause may be partly due to a crowding in this part of the floral axis (lack of growth) and this crowding and the sterilization of sporophylls associated with it, may in turn be due to the conflict of activity and latency of the hereditary factors at this transition zone between the vegetative and reproductive parts of the axis, in which zone, owing to a rapidly changing gradient in the determinate axis, many vegetative hereditary factors are becoming latent while reproductive, sporophyll-producing factors are becoming active. A rapid physiological change, or crowding, would,

therefore, produce a conflict of reactions. Whatever the cause may be, the sterilization of the base of the flower with the display of color when it goes a little above the first steps of its development, i. e., the evolution of the perianth, is one of the most interesting among the many interesting phenomena of flower development.

The bisporangiate strobili of the heterosporous Selaginellas do not have their sporophylls arranged in such an invariable order as we find in the Anthophyta and Bennettitales. The megasporophylls may be at the base of the cone or more or less scattered along the floral axis or in alternate zones with the microsporophylls. As stated above, all the evidence available goes to show that the original heterosporous flowers were bisporangiate and that from this condition, from a very low evolutionary level to the very highest type of floral evolution as represented by the Compositales, there have been numerous lateral progressions, on every level and in almost every prominent group, to the monosporangiate condition, either resulting in one of the various types and degrees of moneciousness or in the more extreme diecious condition.

Not only do the primitive flowers represented by the various types of strobili, show prominently the progressive reduction of the floral axis and a crude development of a perianth, but other characteristics which appear in the higher forms are also evolved. The change from the green color of the primitive sporophyll is to be seen in the yellow cones of some Lycopods, in the chlorophylless cones of the four highest species of Equisetum, in the cones with special colors of some Cycads, and especially in the highly colored staminate and carpellate cones of some wind-pollinated conifers, especially in species of Picea, Larix, and Pinus, where the colors, including yellows, blues, violets, and reds, are usually most prominent at the time of pollination. In some of the most extremely specialized carpellate cones, as in some species of Chamaecyparis and Juniperus, the blue and purple colors are more especially produced in the mature fruiting stage.

Zygomorphy also shows itself to some degree, especially in various highly evolved pines, as *Pinus sabiniana*, *P. coulteri*, *P. radiata*, and *P. contorta*. Thus, as will appear from the more detailed account of floral development in the Angiosperms,

nearly all the fundamental specializations of the higher flowers are shown to a greater or less degree in the three preceding subkingdoms.

THE ANGIOSPERM FLOWER.

A typical flower of the more primitive type of Angiospermæ or Anthophyta may be defined as a hypogynous, spirally actinomorphic, bisporangiate flower with numerous parts indefinite in numbers, with the megasporophylls above and the microsporophylls below, and with an undifferentiated perianth theoretically derived from stamens or microsporophylls. All other types of living angiospermous flowers are plainly derived from this type. Of course, there are various other peculiarities in the angiosperm flower, as closed carpels forming an ovulary, a special stigma for pollination, greatly reduced gametophytes, very long pollentube, triple fusion, development of a xeniophyte, etc., but these are developments of or in the floral organs, rather than of the flower itself. The evolution of the flower may be reduced to five general, primary causes, as follows:

First. The progressive reduction of the floral axis through the earlier and earlier stopping of growth or determination of its terminal bud, leading to reduction of parts, coalescence or common development of parts which were once separate organs, and epigyny in which case the tip of the bud ceases its development before the floral organs have appeared and these are then developed from the further growth of the cortical region, the carpels in the extreme cases being merely more or less united vestigial structures capping the cavity of the ovulary, which is produced by the invagination of the cortical wall of the stem through growth. The ovules then develop from this wall rather than from the vestigial carpels themselves.

Second. The lateral expansion of the floral axis, either the part of the axis bearing the perianth and andrecium, the carpel-bearing axis remaining normal, giving rise to an hypogynous hypanthium, usually called a perigynous disk; or the carpel-bearing part of the floral axis alone expands as in Nelumbo; or the entire floral axis expands giving rise to cup-shaped receptacles as in Calycanthus; or the gynecium axis and the part of the axis bearing the perianth and andrecium both expand separately as in Fragaria. In the epigynous type of flower, the part of the cortex or axis bearing the perianth and stamens may

also develop, giving rise to the epigynous hypanthium, as in Cereus, Oenothera, etc. In the hypogynous type of hypanthium or perigyny, the hypanthium and outer carpellary parts may develop as a more or less common tissue, giving rise to the apple type of flower.

Third. The change of the flower from its primitive position as a terminal organ to a lateral or axillary position brings in a new relationship of one axis to another axis and often also a new up and down relation to gravity, resulting finally in bilateral or zygomorphic flowers. The bud develops more on one side than on the other, destroying the primitive symmetrical time-space relation of the leaf incepts, which originally gave rise to a spiral, actinomorphic symmetry of the shoot. How far the mere position of one axis on another, with its up and down and right and left relations, may be responsible for the evolution of zygomorphy is not evident. In the mosses, like Buxbaumia, for example, an erect radially symmetrical embryonic sporophyte, growing on an erect radially symmetrical gametophyte, finally develops a bilateral, more or less dorsiventral sporangium. There are, therefore, several fundamental causes combined in the adjustment and evolution of zygomorphic flowers and axes. Nevertheless, one can see even on a side-branch coming from an erect axis of a tree that such a branch is not radially symmetrical, but more or less bilateral or zygomorphic with an eccentric pith. Lateral branching systems are often decidedly persistently bilateral as in some Araucarians. The progressive development of zygomorphy from the original radial symmetry has a very decided influence on the evolution of the floral structures resulting in one-sided loss of parts and one-sided specializations or unions. Sometimes an isobilateral development comes about, although this is comparatively rare, and these isobilateral systems may also progress to zygomorphic systems. In rare cases, factors of irregular development are introduced which may transform a zygomorphic flower into a mature unsymmetrical type, as in Canna, which shows a complete series from spiral to cyclic actinomorphic condition, to zygomorphic structure, but finally becomes unsymmetrical in appearance through the irregular development of its staminodes and other organs.

Fourth. The relation of the time of sex determination to the ontogeny of the floral axis has been discussed somewhat

above. In the Angiosperms, the primitive, bisporangiate type of flower passes from the neutral, vegetative condition, with no sexual state present, to a male state or at least to a state that leads on to maleness in the andrecium and then reverses promptly and usually sharply to a female state or a state leading to femaleness in the gynecium, which state continues until growth of the flower bud ends. The original step in the evolution of the time of determination of the sexual state after it was transferred from the gametophyte of the homosporous plants to the sporophyte of the heterosporous plants is shown in such species as *Marsilea quadrifolia,* where the megasporangia and microsporangia arise side by side from the same tissue in the sorus. The next step was taken by such plants as Azolla, where only one kind of sporangia are produced in a sorus, but each sorus shows vestiges of the other sporangia, and both kinds of sori occur on the same leaf. The third step is represented by all normally developed, living, heterosporous species, where the time of sex determination is transferred back at least as far as to the incept of the sporophyll, giving rise to distinct microsporophylls and megasporophylls. The first arrangement in this type was probably a more or less intricate mixture of microsporophylls and megasporophylls as is still the case in some Selaginellas, and the second or higher type, characteristic of the Anthophyta, would come in with a more perfectly evolved, determinate axis in which the physiological gradient is progressively modified toward the tip and in which a zonal arrangement of sex-determination naturally follows, the male state coming first and the female state later, according to the peculiar hereditary constitution possessed by the Angiosperms and some other plants.

The first step in specialization of the sexual system was then to evolve hereditary systems in which some floral axes, in the normal environment, develop a male state and some a female state at the beginning of sporophyll production, which resulted in the monosporangiate type of flowers, and in case of primitive strobili apparently without vestiges of the opposite type of organs. But in the more complex, more highly evolved Angiosperms and some of the highest Gymnosperms, the Gneteæ, all sorts of gradations of vestigial stamens and carpels are produced. In the extreme condition, both monecious and diecious, no vestiges are developed under normal conditions, as in *Cannabis;*

sativa. Such plants as the hemp, however, can easily be induced to develop bisporangiate flowers with the proper environment. By throwing the time of sex determination still further back in the ontogeny more extreme types of moneciousness are produced. In one type which is rather common staminate and carpellate flowers are produced in progressive zones, either the one or the other being developed first. In this case the inflorescence bud must undergo reversal and in passing from one sexual state to the other, it must necessarily pass through the neutral condition which may sometimes give rise to a zone of neutral tissue of some width. In this case a perfectly normal bisporangiate flower, a sex mosaic, or some monstrosity may develop, as would be expected. If the time of sex determination is shoved back into the seed or fertilized egg, a diecious sporophyte results. The flowers of such plants show the same kind of potentialities in the development of vestigial sporophylls and the bisporangiate condition as monecious species. In case a diecious species is closely related to a species with bisporangiate flowers and in case its hereditary constitution is such that the sexual states are not strongly fixed, then, if bisporangiate flowers are developed abnormally, the original sequence of stamens first and carpels last may be entirely lost and a stamen or a carpel may appear at any point or in any relation on the floral axis. A typical example of this kind is *Thalictrum dasycarpum*. It is evident, therefore, that vestigial sporophylls are due to two entirely different causes: First, the phylogenetic reduction of the floral axis, and second, the change in the time of sex determination.

For some reason not entirely clear to the writer, monosporangiateness is exceedingly rare in typical zygomorphic flowers, especially when they are far along in the line of zygomorphic specialization. With a moderate development of zygomorphy monosporaigiateness may be present as in the monecious *Aesculus glabra* and *Musa sapientum*. In the Compositales, monosporangiate flowers, either monecious or diecious, are rather common in the actinomorphic Helianthaceæ and Ambrosiaceæ, while they appear to be entirely absent in the Cichoriaceæ, in which all the flowers are ligulate and thus zygomorphic. The same general tendency may be seen in the zygomorphic Scitaminales, Orchidales, Scrophulariales and Lamiales. In the Fabaceæ also monosporangiate flowers occur

in the actinomorphic groups and are rare or absent in the higher zygomorphic groups.

It may be that in extreme cases of stamen reduction, pollination would become too precarious for the perpetuation of the species should monosporangiate conditions arise. Highly evolved zygomorphic species, on the other hand, frequently develop cleistogamy or parthenogenesis as in violets, bladderworts, and dandelions. But similar evolutions occur in actinomorphic series and in extreme wind-pollinated species as in Specularia, and in wheat.

Just as various specializations of the flower lead to self-pollination, so others result necessarily in cross-pollination. Among the most definite conditions leading to cross-pollination are dieciousness and proterandry and proterogyny.

Since monosporangiateness appears to be more abundant in the higher types of Angiosperm flowers than in the lower, and since these higher types are commonly reduced in size and often apetalous, and since wind-pollination is also a derived specialization, it happens that the flowers of wind-pollinated Angiosperms are usually though not always inconspicuous; while in the more primitive Coniferæ the large strobili may be very conspicuous, colored objects even though monecious and wind pollinated. In the higher types of conifers and joint-firs (Gneteæ), there is also a decided reduction of the flower as shown by such groups as Taxaceæ, and Juniprus when compared with the very primitive Araucariaceæ or some of the lower genera of Pinaceæ. When one looks into the matter, however, one finds large numbers of very minute and inconspicuous flowers among the higher insect pollinated species also.

Fifth. In the evolutionary progression of the flower from the primitive, green strobilus with only slightly modified sporophylls, there has occurred a great increase in the diversity of hereditary factors which give expression to minute characters in the floral parts. This complexity in the higher species shows itself in the development of various chemical contents, especially in color substances; in diversity of surface appearances; in appendages of various kinds; in peculiar shapes and forms, as specially developed crowns; in color patterns of almost endless variety, especially in the corolla, but by no means confined to it; in many types of stamens, pollen, and pollen-masses; in the special development of petal-like staminodes; and in the

diversity of nectar-producing surfaces, pits, spurs, disks, hairs and the like.

These five general types of evolutionary activities—shortening of the floral axis, expansion of the floral axis, zygomorphy, displacement of the time of sex determination and reversal, and development of the complexity of special morphological and physiological hereditary factors—have produced an almost endless diversity of floral form, structure, and quality, and have made the flower a very important organ for determining phyletic relationships. So far as fundamental types are concerned, all flowers may be reduced to eight morphological systems and can be represented by eight general diagrams, which with few modifications can be used to represent all the structures, and relations necessary for a proper study of floral evolution. These eight types of flowers, as indicated in the modification of the floral axis, are as follows:

1. Hypogynous, with no special distortion or expansion of the floral axis. Examples—Magnolia, Lilium, Geranium. Fig. 2.

2. Hypogynous with expanded gynecium axis. Example—Nelumbo. Fig. 4.

3. Perigynous, with free hypogynous hypanthium and normal gynecium axis. Examples—Geum, Rosa, Rhexia, Baptisia. Fig. 7.

4. Perigynous with the entire floral axis expanded continuously, bearing all the floral organs on a broad disk. Example—Calycanthus. Fig. 5.

5. Perigynous, with separately expanded gynecium receptacle and hypogynous hypanthium. Examples—Fragaria, Duchesnia. Fig. 6.

6. Perigynous with adnate hypanthium. Examples—Malus, Amelanchier. Fig. 8.

7. Epigynous, without hypanthium. Examples—Hypoxis, Cypripedium, Asarum, Helianthus. Fig. 9.

8. Epigynous with epigynous hypanthium. Examples—Euryale, Cereus, Fuchsia, Curcurbita. Fig. 10.

Of these eight types, Numbers 2, 4, and 5 are rare, and 6 is also restricted. The vast majority of flowers are developed upon the plans represented by Numbers 1, 3, 7 and 8.

It must be recognized that there are occasionally transitions between these types and in characterization of any species or representing it by the appropriate diagram it must be referred to the type to which it has the nearest affinity.

TERMINOLOGY.

The terminology of the flower is still far from satisfactory. Selecting the terms that appear to be the most suitable, the angiosperm flower may be described as follows:

- Flower
  - Sporophylls (Fertile or Sporebearing Organs)
    - Gynecium (Carpel set)
      - Carpel or Megasporophyll
        - Stigma
        - Style
        - Ovulary
          - 1 or more ovules (Modified megasporangia)
    - Andrecium (Stamen set)
      - Stamen or Microsporophyll
        - Anther
          - Mostly 2 or 4 Micro-sporangia (Pollen-sacks)
        - Filament
  - Perianth (Sterile Organs)
    - Corolla (Petal set)
      - Petal
    - Calyx (Sepal set)
      - Sepal

Some flowers have, of course, only a part of this complete set of floral organs. In extreme cases there may be only a single stamen or a single carpel.

Flowers are bisporangiate, monosporangiate, or in extreme cases completely sterile. If monosporangiate, then the flowers are staminate and carpellate and the plants either monecious or diecious. When the plants are diecious the individuals are either staminate or carpellate.

Flowers are (1) spiral or cyclic (special type of spiral);
(2) hypogynous, perigynous, or epigynous;
(3) symmetrical or rarely unsymmetrical.

If symmetrical, flowers are spirally symmetrical, or cyclically symmetrical. The symmetry is actinomorphic, radially symmetrical in two or more planes; isobilateral, symmetrical in two planes making different types of halves; or zygomorphic, with only one plane of symmetry.

If the flowers are cyclic, they may be dicyclic, tricyclic, tetracyclic, pentacyclic, etc.

The parts in a cycle may be dimerous, 2-parted; trimerous, 3-parted; tetramerous, 4-parted; pentamerous, 5-parted; hexamerous, 6-parted, etc.

Corollas are choripetalous or sympetalous, or the flower may be apetalous.

The calyx is chorisepalous or synsepalous, or the flower may be asepalous.

The flower may be entirely without a perianth or naked.

The gynecium may be apocarpous or syncarpous, simple or compound; and in respect to cavities, the ovulary may be unilocular, bilocular, trilocular, quadrilocular, quinquelocular, plurilocular, etc.

The stamens may be free, or synantherous, or if the filaments are united in various ways, monadelphous, diadelphous, triadelphous, etc.

OBSERVATIONS ON SPECIAL FLORAL PHENOMENA.

POLLINATION.—Primitive pollination was probably merely accidental, either on the ground or on the plant by means of wind, rain, gravity, or animals. From this unspecialized condition various types evolved, in the Gymnosperms mostly wind pollination, but to a small extent insects are also agents. In the Angiosperms the evolution was first to the undifferentiated type of insect pollination, which is the lowest type in the living species, and from this type in various lines the progress was to wind pollination (anemophily), which may arise even in the highest groups, (2) to water pollination (hydrophily), comparatively rare, (3) to specialized animal pollination (mostly entomophily), and (4) to various types of cleistogamous flowers and self-pollination. Cleistogamy has arisen from both the entomophilous and anemophilous conditions. The undifferentiated entomophilous flower usually has very complete pollination, while the highly specialized adaptations to insect pollination are often very inefficient, resulting only in a small percentage of pollinated stigmas, as for example, the common milkweed (*Asclepias syriaca*) in which the writer found less than one in eighty flowers pollinated in some localities in spite of the presence of many species of insects which visited them. Various types of self-pollination are also very efficient as for example the wheat and violet. Most of such evolutionary developments of the flower have no causal relation in advantage or utility. Some entomophilous species have self-pollination.

As a general rule, the lower types of flowers are necessarily large and conspicuous, while most of the very highly specialized types, whether petaliferous or apetalous, entomophilous, anemophilous, or hydrophilous, are small and inconspicuous. This inconspicuousness is, however, often compensated because of the massing together in large inflorescences, as for example the staminate catkins of *Populus deltoides*, the heads of *Bidens connata*, or the spikes of *Ibidium beckii*. Many flowers have nectar glands and are visited by insects for the nectar, as well as for pollen, but that there is no direct causal relation between the evolution of nectar glands and the advantage of insect visits to insure pollination is shown by the presence of prominent nectar glands on the leaves of such ferns like *Pteris aquilina*, which are visited by various insects. In certain species also, like the higher blue violets, the conspicuous flowers visited by insects are poor seed producers as compared with the cleistogamous flowers produced on the same individual. Such cases contradict completely the old utilitarian, selection hypothesis. The presence of nectar glands in flowers is then to be explained on the same basis as the presence of similar glands on the leaves and stems of both flowering and flowerless plants.

Double Flowers and Staminodes.—Since petals are sterilized stamens, any physiological factor evolved in the plant which changes the time or point of petal expression may cause other stamens to change to petals. Petal-like staminodes are common in various groups. Florists take advantage of this condition and by selecting such mutations have developed large numbers of so-called double flowers. In the composites the tendency to produce ligulate or zygomorphic corollas has given the so-called double composities. The tendency to sterilize the marginal flowers of other types as in Viburnum has given forms like the snowball. Such extreme mutations could of course not survive except through the care of man.

Decrease in the Number of Stamens.—In the vast majority of cases the evolution of the flower tends regularly toward the reduction of both stamens and carpels. If the flower is actinomorphic, the orthogenetic series pass from spirals of stamens of indefinite numbers to a definite condition of three or four cycles and then to two cycles, a common half-way station being the pentacyclic condition of the flower. This is followed by the elimination of the inner or outer cycle. But a

further reduction may occur leaving but two or one stamens. When zygomorphy appears, which is usually not until the flower has become at least partly cyclic, the two-cycled andrecium of a Monocotyl gives rise to the series, 6, 5, 3 (parts of 2 cycles), and then ends with either 2 or 1 stamens. If an unsymmetrical factor is introduced at the final stage, only a half functional stamen may remain in the flower. In the first transition from 6 to 5, the suppressed stamen may develop again here and there in the flower cluster, as in the banana (Musa). In the Dicotyls similar orthogenetic series are developed, from spiral to a two-cycle andrecium and then to one cycle. The higher Dicotyls are mostly tetracyclic and pentamerous. With the advent of zygomorphy the series passes from 5 stamens to 4 through all gradations of reduction and then to 2 and occasionally as in Salvia to 2 half stamens. And here also lost stamens may reappear in individual flowers as for example in Catalpa, which has two functional stamens and three prominent vestiges. By a careful search of a large number of flowers one can usually find among the normal type, here and there, flowers with 4 stamens, the two lateral vestiges being restored to the normal condition. Apparently such cases arise through some unusual physiological condition which prevents the inhibatory factors from bringing about a prompt determination.

Special Mutative Changes.—Species may change the usual plan of their flowers by a direct mutation, as a three spiral or three-parted condition to a two-parted one, or a five-parted set to a four-parted set or cycle. In such cases also, if the given species is near the original type, reversions are common in individual flowers, as in the common lilac (*Syringa vulgaris*) in which one can commonly find flowers with pentamerous corollas among the more typical tetramerous corollas which represent the derived type. Phenomena of this nature are very common all through the Anthophyta and must be properly understood before a correct disposition can be made of the phyletic relationship of the species involved.

Evolution of the Perianth.—In the more primitive Anthophyta, there is often little or no difference between the inner and outer sets of perianth segments. Sometimes there is but a single cycle which may be very brilliantly colored. From this undifferentiated condition, the series passes up on the one hand to differentiated cycles, a modified outer calyx often

green and of leaf-like texture, and an inner corolla, or on the other hand to a reduction or complete loss of one or both sets of the perianth segments. Usually some vestige remains, however, and completely naked angiosperm flowers are rare, except in the most extremely specialized species, where one meets with them occasionally. The evolution may also proceed, apparently, to the differentiated colored corolla and green calyx and then on from this condition to the elimination of one or both sets. Such eliminations are, of course, merely results of the evolutionary shortening of the floral axis. In the composites, loss of the corolla is comparatively rare, but few species have any prominent vestiges of the original calyx. In some the calyx is represented by a mere, slight ridge while in great numbers a new structure appears, the plumose pappus, which often evolves to a remarkable structure as in Tragopogon. In the lower type of flowers the perianth segments are entirely free, but as one goes up the evolutionary series there is a greater or less union of the segments, either in separate cycles or sometimes the inner and outer both together in a common structure. Sympetalous corollas also have adnate stamens abundantly. All such unions are to be ascribed to the shortening and modification of the bud of the floral axis, the cell differentiation process overtaking the cell development or cell lineage, the different processes of growth and hereditary expression being telescoped together, so to speak.

Evolution of the Gynecium.—The primitive gynecium consists of numerous free carpels, indefinite in number and spirally arranged. From this condition the evolution of the series is to a single cycle of free carpels, usually 3 in Monocotyls and 5 in Dicotyls. The next step is usually the union of these sets with as many cavities in the ovulary as carpels represented. But the evolution may continue without coalescence to a single carpel with one cavity. The usual course, however, is for the gynecium with a plurilocular cavity to be reduced to a single cavity, as a result of the continued earlier determination of the floral axis. Commonly part of the carpels become vestigial or disappear in this process. In Monocotyls, there are often only two stigmas left with a vestige of the third, as in the higher grasses, or only one, as in some Sparganiums. Such reduced gynecia then often look superficially like single carpels, although they are actually the culminations of originally com-

pound structures. In Dicotyls, an ovulary with five cavities is very frequently met at the half-way station up the evolutionary series. This may change directly to a unilocular ovulary with five stigmas, but commonly the stigmas are reduced to three and then to two, in either of which conditions the unilocular ovulary may evolve. Practically all the higher types of Anthophyta, both Monocotylæ and Dicotylæ, have such reduced, pluricarpous, unilocular gynecia, and it is only rarely that the unilocular condition is attained when the carpels are still numerous.

EVOLUTION OF THE INFLORESCENCE.

As stated above, primitive flowers are developed at the ends of ordinary leafy branches, the foliage leaves merging over into the sporophylls. A somewhat higher type appears in the shifting of the reproductive differentiations to the axillary buds of ordinary foliage leaves. From these two conditions, both of which may be present on the same plant, there is a gradual development of the flower cluster to the condition represented by the raceme, corymb, panicle, and cyme. These types are found in all degrees of development. By the introduction of branching factors which manifest themselves mainly in the reproductive shoots very complex panicles may be developed. On the other hand, complex flower clusters may evolve as the result of contraction or earlier determination of vegetative branching systems. Among the lower plants, flower clusters become evident in the Lycopods. *Lycopodium annotinum* represents the primitive condition with single or solitary strobili at the ends of leafy branches. *L. clavatum* usually has two cones on a specialized peduncle and this represents the simplest cluster possible. In *L. obscurum* there is also a beginning of clustering, although no special peduncle is developed. In *L. complanatum* the inflorescence is well evolved, because of repeated dichotomous branchings of the peduncle, commonly giving rise to eight or more cones. Among Conifers, a highly specialized staminate inflorescence is found in Taxodium. The numberous small staminate cones are borne in long, terminal, drooping, spike-like, branched panicles and the carpellate cones are usually also produced in small terminal clusters. In the Gneteæ, highly developed spike-like inflorescences are produced, which in the case of Tumboa and Ephedra simulate single

conifer strobili, and in Gnetum often look very much like ordinary aments.

Beginning then with a racemose or paniculate type of inflorescence, a simple or compound umbel, or a much-branched, flat-topped cyme or corymb represent some of the more specialized conditions. The first can be derived from a raceme by simply shortening the primary axis, leaving the pedicels of the individual flowers unchanged. The flat-topped cymes, like those of Sambucus and Viburnum, are extreme clusters in which a complex branching character has appeared and in which a high degree of differentiation is expressed. Such cymes and umbels may have the outer marginal flowers enlarged and sometimes sterilized as in *Viburnum opulus*, as stated above. Such sterile, conspicuous, marginal flowers are also present in the corymb of some Hydrangeas. By the addition of another hereditary factor, the sterile heredity may be expressed in the entire or nearly entire cluster, much the same as the tubular flowers of a Composite can all be transformed into ray flowers. Such a change has taken place in *Viburnum opulus*, giving rise to the well-known ornamental shrub called snowball.

If the main axis of a raceme remains unchanged, but the pedicels of the individual flowers are not developed, the result is a spike, and if the axis of such an inflorescence becomes fleshy we have a spadix. An ordinary spike which evolves a highly specialized slender, flexible axis is a catkin or ament. Panicles may also be reduced to spike like panicles. Among the most extreme inflorescences are heads, disks, and cyathia. These may arise from almost any of the preceding types by a shortening of all the axes in the inflorescence, which simply means a very early determinate growth of the system and consequently early process of special differentiation. Frequently in such inflorescences a considerable part of the stem below the flower-bearing part is involved in the shortening process, giving rise to involucres whose bracts are more or less modified leaves. If such plants are subjected to special manipulation, as severe cutting back at the proper time, the normally contracted part of the inflorescence axis will be somewhat elongated, in which case some of the involucral bracts will develop as normal leaves again. Such results can be brought about readily in *Helianthus annus* and *Arctium minus*, for example. A similar result follows in Helianthus if the plants are grown with a short daylight period.

The evolution of the inflorescence, therefore, follows in a general way the same lines as the flower itself. The extreme forms result from the earlier and earlier determination of the inflorescence buds, resulting in the massing together of the expressions of many hereditary factors. The differentiation thus overtakes the cell lineage or cell-division processes and the ontogenetic sequence is telescoped. In extreme inflorescences, highly colored bracts are often conspicuous features as in Poinsettia and other Euphorbias, in *Cynoxylon floridum*, and in various Aroids.

In the evolution of the more prompt determination of the inflorescence bud, the modification of a raceme, panicle, cyme, etc., may result in a reduction to a solitary flower. Such single flowers, as might be expected, are often large and conspicuous. They are never to be confused with the primitive type of solitary flowers, either terminal or axillary. Usually the character of the flower, its peduncle, the plant itself or a comparison with its near relatives will indicate whether such solitary flowers are of the primitive condition below the flower cluster stage or whether they have been derived by reduction from an inflorescence.

When there is an extreme condition of the inflorescence axis so that the differentiation processes overtake the cell development processes, the resulting cluster often simulates a single flower. So strikingly similar is the result that people in general who are not especially acquainted with floral structure almost invariably mistake such clusters as those of the composites for individual flowers. Such mimicry has no casual connection with any ecological selective agency as was formerly supposed, but the similarity of form is the result of a contracted life history of the inflorescence and flower shoots through which the factors become active in tissues and cells where formerly they were latent until the floral axis itself had been developed. As stated before, these are extreme cases of earlier determinations causing the differentiation process to overtake the ontogenetic development of the tissues.

As examples of such extreme developments the following may be mentioned: The cyathium of *Tithymalus corollata* develops five large petal-like bracts which makes the inflorescence look remarkably like an individual flower. Euphorbias have long ago lost their five petals, but petal factors are still

present, as well as a five spiral phyllotaxy which express themselves in the bracts developed from the mass of tissue developing the cyathium. *Parthenium integrifolium* usually has five marginal ligulate corollas corresponding to the five petals, etc., it has in its individual flowers. The same is true of the heads of *Ptiloria pauciflora*. Great numbers of such mimicking inflorescences, of course, do not have these numerical relations, since the expansion of the tissues of the disk rather tends, commonly, to increase the number of parts produced. The inflorescence of *Cynoxylon floridum* also simulates a single large flower because the four white bracts look superficially like petals. The inflorescence of the common fig, *Ficus carica*, is another extreme type in which the inflorescence develops as a hollow stem with the small flowers inside giving rise to a peculiar club-like structure. There is no mimicry of a flower, because the structure contains no bracts on the outside and because there are probably no petal factors left in the plant. Such extreme examples of inflorescences could be greatly multiplied, but these common types given are enough to indicate the general evolutionary trend.

INCORRECTNESS OF UTILITARIAN AND TELEOLOGICAL EXPLANATIONS.

A final word of criticism may be given in regard to a certain type of flower literature, voluminous in the past and still coming out in large quantities from both popular and supposedly scientific sources. With the advent of the doctrine of special design, of the utilitarian philosophy, and of the theory of the origin of species through natural selection, all types of minds could indulge in teleological abstractions and thus teleological literature in respect to the flower especially become both rampant and great. Both the popular and scientific literature on the flower of the immediate past are scientifically incorrect and often as ludicrous as the wildest flights of the "nature philosophers" of a hundred years ago, and both the wise and the foolish are still nourished with pabulum as follows: "Today we know that the manifold varieties of floral forms we see are mainly devises developed by the plant to secure the perpetuation of the species." "Plants have provided themselves." "Such flowers are rigid economists except in the matter of pollen, of which they are profligate spenders. Color, scent, and sweetness

are absent." "Honeysuckles and similar plants constrict their corolla so that only insects with long tongues can reach the sweets at its base." "To keep out the uninvited." "Each one of them (plants) has a purpose of its own from which nothing can turn it." "The plant lives only to produce its seeds." "After a while you will see why it needs so many more stamens than pistils." "The bright blossoms which it puts out are only to attract its messengers, the pollen carriers."

And so on, ad infinitum! Now the writer himself believes in a universal design in the creation, although a "special design," or a special utility, is far from his thoughts. He holds no anarchistic philosophy, scientific, political or otherwise. He has "communed" with plants poetically and scientifically since childhood, but never once has a plant told him that it desired to perpetuate its species, any more than the prairie fires he used to see long ago ever told him that they wanted to burn up everything in sight, although there is no doubt that they actually did do it. In fact, instead of imbibing in an unadulterated form the easy-going explanations of a utilitarian teleology, he was taught to believe, both from his contact with nature and from what to some appeared to be a rather stern catechism, that whether or no, "God works when and where and how He pleases." And this has always acted as a considerable check on his poetic flights of fancy. For what was the use to look for special designs and utilities if things go thus? They might be present or not.

But when all is said in a scientific way, flowers still have an esthetic and moral value that must not be overlooked; for this is just as fundamental and important as the scientific discovery of relationships and evolutions. It is not at all necessary, however, to present the moral and esthetic value of flowers in a false, utilitarian and telelogical dress.

EXPLANATION OF PLATE I.

Diagrams of the eight fundamental types of flowers. For particular information in respect to this method of representing floral diagrams, see "A General System of Floral Diagrams," Ohio Jour. Sci. 16:360, 1916. In representing spirals the actual pitch of the screw is not indicated except in the case of cyclic flowers, since this often requires considerable accurate measurement and complicated construction. For flowers with variable numbers an attempt is made to represent the most common type.

Fig. 1. Primitive homosporous flower corresponding in type to the primitive hypogynous type in the Anthophyta. Small cone from side branch of *Equisetum praealtum* Raf. The spirals are variable, as well as the sporophylls in each spiral.

Fig. 2. Hypogynous flower of *Scheuchzeria palustris* L., also of *Cabomba caroliniana* Gr. Hypogynous, actinomorphic, bisporangiate, pentacyclic, trimerous, choripetalous, apocarpous.

Fig. 3. Hypogynous flower of *Convallaria majalis* L. Same as Fig. 2, but syncarpous, and the perianth segments all united into one tube and the stamens united with the tube.

Fig. 4. Hypogynous flower with expanded gynecium axis of *Nelumbo lutea* (Willd.) Pers. Hypogynous, bisporangiate, mainly actinomorphic and spiral, with a general but distorted 3-spiral plan, apocarpous, and choripetalous with petal-like staminodes.

Fig. 5. Perigynous flower with the entire floral axis expanded continuously, bearing all the floral organs on a broad disk. *Calycanthus floridus* L. Flower on a spiral plan, apocarpous choripetalous, with no sharp distinction between sepals and petals, and with 6 vestigial stamens.

Fig. 6. Perigynous flower of *Fragaria chiloensis* (L.) Lam. with separately expanded gynecium receptacle and hypogynous hypanthium. Perigynous, bisporangiate, on the 5-spiral plan, actinomorphic, choripetalous.

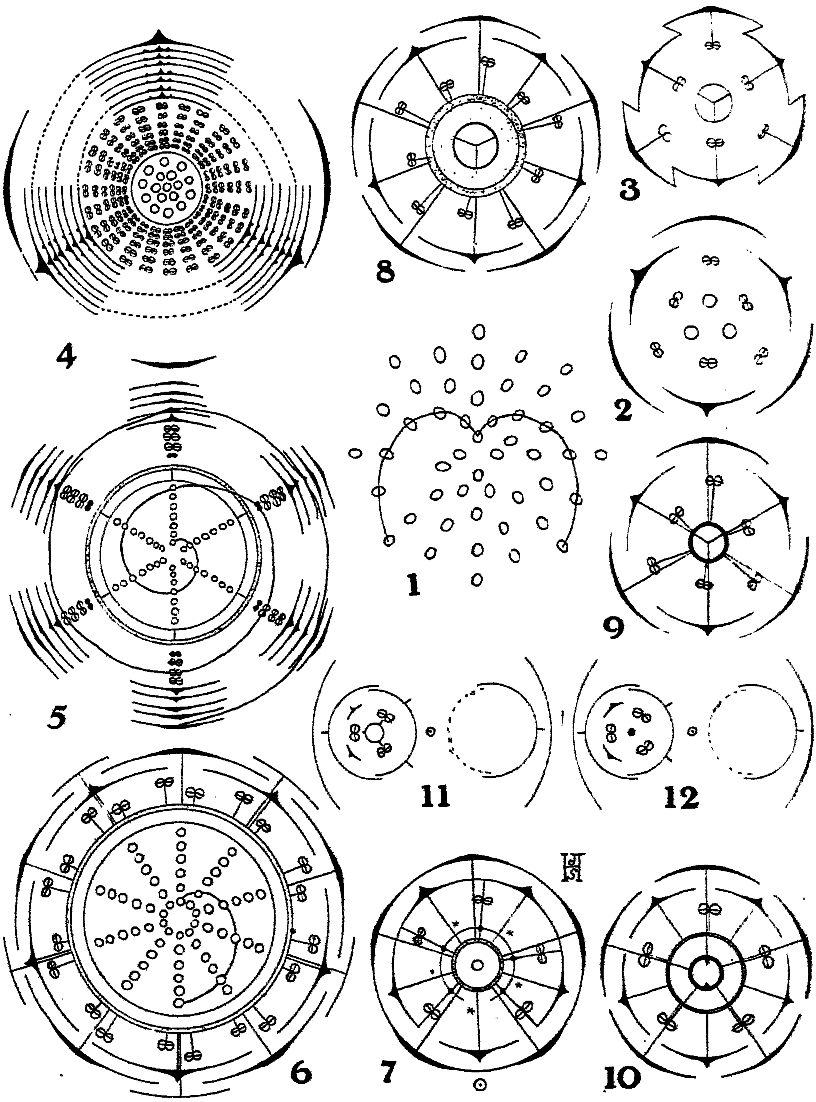
Fig. 7. Perigynous flower with free hypogynous hypanthium of *Petalostemon purpureum* (Vent) Rydb. Perigynous, bisporangiate, zygomorphic, tetracyclic by the loss of one cycle of stamens, pentamerous except the gynecium, which has one carpel, with four petals united, and with the stamen filaments united into an open tube which is united with the four united petals.

Fig. 8. Perigynous flower with adnate hypanthium of *Crataegus crus-galli* L. Perigynous, bisporangiate, actinomorphic, pentacyclic, choripetalous, pentamerous except the gynecium, which is trimerous and syncarpous.

Fig. 9. Epigynous flower without hypanthium of *Hypoxis hirsuta* (L.) Cov. Epigynous, bisporangiate, actinomorphic, pentacyclic, trimerous, chorpetalous, syncarpous with trilocular ovulary.

Fig. 10. Epigynous flower with epigynous hypanthium of *Ribes odoratum* Wendl. Epigynous, bisporangiate, actinomorphic, tetracyclic, choripetalous, pentamenous, except the gynecium, which is bicarpellate, syncarpous, and with a unilocular ovulary.

Figs. 11 and 12. Diagrams of sessile and stalked spikelets of *Andropogon furcatus* Muhl., the first with a reduced, hypogynous, bisporangiate flower and a lemma of a vestigial flower, the second with a hypogynous, monosporangiate flower, staminate through extreme reduction, and a vestigial lemma.



Diagrams of the types of flowers.

THE DIGESTIVE TRACT OF LONGISTIGMA CARYAE (HARRIS).*

GEORGE F. KNOWLTON,
Department of Zoology and Entomology, Ohio State University.

INTRODUCTION.

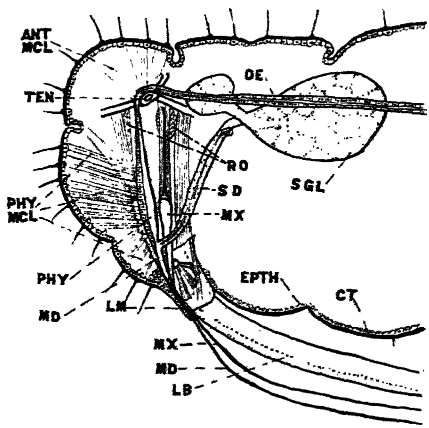
This work was undertaken because of the author's interest in Aphididæ, and the desire to become better acquainted with the internal structure. The Sycamore Aphid was chosen because of its large size and availability. All specimens studied were oviparous females containing eggs, collected between October 3rd and November 24th. Due to the unusually dry fall and the lateness of the season, it is doubtful whether even those earliest collected were obtaining much if any sap, which would possibly account for the stomach being closed for most of the distance in all cases. Specimens taken in early October showed signs of recent digestion in the epithelium of the mid-intestine, but those taken later had the cells more normal and showed practically no shedding of the cells. Even in late September the aphids were usually found with the mouth parts attached to the bark, unless they were on the under side of the twigs, ovipositing.

The Author is much indebted to Dr. C. H. Kennedy, under whom this work was carried on, for his suggestions and criticisms as the work progressed.

The digestive tract consists of a rather simple but slightly coiled tube, lying for the most part on the ventral wall of the abdomen (Plate I, Fig. 2). For a short distance the tube is complicated by the anterior end of the mid-intestine doubling back and forming a loop through the muscle wall of the posterior end of the mid-intestine and the anterior end of the hind-intestine (Plate I, Figs. 2 and 3). This loop enters through the muscle wall of the hind-intestine and enlarges (Plate I, Fig. 3 —Oe. V.) where the folds of the œsophageal valve return and join the stomach epithelium (Plate II, Fig. 1). Following the transition from fore- to mid-intestine, the stomach makes an

* Contribution No. 82 from the Department of Zoology and Entomology, Ohio State University.

S-shaped turn before enlarging greatly at the termination of the S into the open stomach until it becomes narrowed, except in a few cases, at the point of exit from being encased in the outer covering, formed by the posterior end of the mid-intestine (Plate I, Figs. 1, 2 and 3; Plate II, Figs. 2, 3 and 4.) In this double section the epithelium (Epth.) of the posterior end of the mid-intestine almost surrounds the anterior ensheathed portion of the stomach, although at no point can the fore end be observed to penetrate this epithelium (Plate I, Fig. 1; Plate II, Figs. 1 to 4). All of the coiled portion of the digestive tract is mid-intestine with the exception of the turn made by the anterior end of the hind-intestine at about the point where the œsophagus passes through its muscle layer.



Right half of head cut near median line, showing the mouthparts with some of the muscles, the salivary glands and duct.

The Gross Anatomy of the Canal.

The attachments consist of the invaginated body wall at the two ends, composing the fore and hind-intestines, with the supporting muscles.

The fore-intestine is comparatively simple in the aphid, lacking the crop and gizzard.

The mouth consists of the labium or lower lip which forms the rather long beak, the labrum or pointed upper lip, the stylet like mandibles and maxillæ that are operated by muscles in the head, and the tube connecting the pharynx with the beak, into which the salivary duct empties. (Text Figure of right half of head).

The pharynx is a sucking bulb supplied with numerous muscles from various parts of the head, but especially from in front. This pharynx relaxes into a rather horseshoe shape with the concave side in front. The pharynx extends nearly up to the tentorium apparently, and is flattened and wider in front of the tentorium, enlarging as it extends down towards the mouth. The pharynx lies behind the large brain, and between the two large nerves connecting the brain with the subœsophageal ganglion.

The œsophagus is a long, slender tube leading from the pharynx, over the tentorium to the œsophageal valve which lies under the muscles of the fore end of the hind-intestine, just before the mid- and hind-intestine come together. There is no indication of outpocketing along the œsophagus to form a crop or gizzard. (Plate I, Figure 2 and text figure of right side of head.)

The œsophageal valve is located just under the muscles at the anterior end of the hind-intestine, and is indicated by the enlargement in size just before the first turn, in the stomach which can be seen through the rather structureless hind-intestine. This valve is partly enclosed in the stomach epithelium which folds back around it, but which is not penetrated at any place by the tube. (Plate I, Figures 2 and 3.)

The mid-intestine is a coiled tube longer than the body, usually quite thick-walled, and lacking gastric cœca. Externally the mid-intestine, or stomach, has a mottled appearance when cleared in Carl's solution. For most of its length the stomach is closed or partly closed in the specimens the author examined, although this would not likely be the case in specimens taken when the food supply was abundant. In the portion where the stomach forms a double tube it is usually open in both sections, with the epithelium of the outer tube wrapped most of the way around the walls of the inner, making it appear at first glance that there is epithelium devloped on both sides of the muscle layer. Cross sections show very plainly that this outer epithelium is continuous with the outer tube epithelium, and that the inner tube has not punctured the latter. Food must pass the full length of the digestive tract to reach the anus. (Plate I, Fig. 2.)

The pyloric valve is not present, and the most evident mark of transition from the mid- to hind-intestine is the ending of the

large epithelial cells of the mid-intestine, and the beginning of the rather structureless and nearly transparent sack like hind-intestine, with its scattered prominent pavement-epithelium nuclei. This transition occurs a short distance before the œsophagus penetrates through the muscles of the hind-intestine.

The hind-intestine lacks the Malpighian tubules, and consists of a sack-like portion that is almost transparent for most of the distance, but connecting with the anus by the thick-walled rectum which has only a small opening through the center. (Plate I, Fig. 2.)

The intestinal valve consists of only a fold around the end of the sack-like hind-intestine, just before the beginning of the rectum. (Plate II, Fig. 9.)

THE HISTOLOGY OF THE ALIMENTARY CANAL.

**The "retortenformigen organen"* that Witlaczil explains and pictures from *Aphis pelargonii* are in many respects similar to those found in *Longistigma caryæ*. These organs lie in the sides of the head, one pair in front of the other, and outside of the muscles that retract the mandibles and maxillæ. In the sycamore aphid these are compressed laterally as shown by Whitlaczil, and the large distal end curves back as in *Aphis pelargonii*, but the proximal end tapers to the place it joins the mandibles and maxillæ. In explaining the origin of these organs Whitlaczil states that they develop from the rudiments of the mandibles and first maxillæ, which sink into the head, taking the skin with them, and are surrounded by the body wall. He goes on to explain that "The retort formed organs show in their fully developed condition, an outer layer of flattened cells which are continuous with the epidermis of the body and consist of a compact mass of large nucleated cells, which under this layer secrete a chitinous substance which hardens first on the point of the organ where it comes in contact with the air, and so forms the outgrowing bristle."

There is a small chitinized tube running up through this "retort shaped organ," largest where it joins the base of the mandibles and maxillæ. According to Whitlaczil, Mecznikow wrongly believed that the bristles were thrust out as in the

* Whitlaczil, Dr. Emanuel. Zur Anatomie der Aphiden, with three tables. Arbeiten aus dem zoologischen Institute der Universitat Wien, pp. 397–441, 1882.

Coccidæ, and in the resting stage rolled up in the "retort-shaped organs."

The cellular structure of the "retort-shaped organs" looks much like partly differentiated embryonic muscle in Longistigma caryæ, and the cells are not so large and distinct as pictured for *Aphis pelargonii*, those in the sycamore aphid being longer and narrower in proportion, and are easily distinguished in sections of the head.

The fore-intestine is histologically composed of the same parts throughout its length, but there is some variation in development of the parts. (Right half of head; Plate II, Figs. 1, 5.) The intima is thin and very delicate for most of the distance through the fore-intestine, which it lines throughout. The epithelium is thin, the cells are cuboid, usually clearly defined, the nuclei of medium size, oval to round and quite centrally located. Nucleus and cytoplasm granular, and nucleoli distinct. The basement membrane is delicate and structureless but can be distinguished. The longitudinal muscles are delicate, scattered strands of muscle at irregular intervals. The circular muscles form a rather continuous, fairly thick layer.

The œsophageal valve very clearly marks the transition from fore- to mid-intestine. The valve consists of a fold of epithelium, delicate cuticula and basement membrane from the œsophagus, which extends well into the small fore end of the mid-intestine and around the turn that occurs a short distance from the beginning of the stomach. The folds of epithelium then turn back to join the large stomach digestive epithelium cells at the point where the tube enlarges perceptibly at the end of the œsophagus. Histologically the parts coincide with the same structures in the œsophagus. (Plate II, Fig. 1.)

The mid-intestine is rather long in the aphid and very easily distinguished from the other parts of the tract. The peritrophic membrane, or some membranous tissue is found covering the inner surface of the digestive epithelium cells in the closed and partly closed portion of the stomach, but is not present, apparently in the open stomach except where no signs of recent digestion are in evidence. The digestive epithelium is composed of large, well defined cuboid cells with large oval to flattened nuclei, the nucleoli prominent and quite large, and the cytoplasm as well as the nucleus granular. In specimens taken early in October (Plate I, Fig. 1) the fore-end of the stomach showed

sloughing off of the digestive epithelium to a large extent, although some cells remained intact. In specimens taken late in November the fore-end of the mid-intestine was open, but little evidence of sloughing off of the cells was apparent. In the closed portion of the stomach (Plate II, Fig. 8) the cells are very large, and the intestine also contracted until there is little, if any, passage way left. The basement membrane is a rather thick, structureless membrane and easily distinguished. The circular muscles lie underneath and are delicate muscles in a discontinuous layer over the length of the mid-intestine. The longitudinal muscles are scattered, delicate strands at frequent but irregular intervals on the outside of the circular muscles.

The hind-intestine is sack-like and more than half as long as the aphid ending in a short, thick walled rectum. The intima is delicate, being thickest in the rectum, but hardly distinguishable in the quite structureless sack-like portion of the hind-intestine. The epithelium consists of flattened cells with indistinct nuclei and with the cell walls seldom distinguishable in the sack-like portion. The fold forming the intestinal valve, (Plate II, Fig. 9) and the rectum is composed of thick, cuboid cells with round to oval nuclei very distinct, and the cell walls clearly defined, nucleus and cytoplasm granular. There is only a slight indication of the six-sided rectum usually found in insects. The basement membrane is thin, structureless, not distinguishable as a rule until the rectum is reached. Here it is thin and structureless. The pavement epithelium is recognized by the large flattened nuclei scattered throughout the sack-like hind-intestine, being the most distinct structure in this rather structureless portion, except for the muscles surrounding it. The inner circular muscles form a discontinuous layer of delicate muscles throughout the length of the hind-intestine, and being most numerous around the rectum. The longitudinal muscles are delicate, scattered strands only. The outer circular muscles are present in strands, but do not appear so frequently as the inner circular muscles.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Longitudinal section through double portion of mid-intestine, showing epithelium wrapped around the inner portion of tract.

Fig. 2. Dorsal view of alimentary canal.

Fig. 3. Double section of intestine much enlarged, showing course of food.

Fig. 4. Cross-section of pharynx with muscles partly relxaed, showing the anterior at A.

PLATE II.

Fig. 1. Oesophageal valve with portion of oesophagus and hind-intestine, and the valve wrapped in the stomach epithelium.

Fig. 2. Cross-section of tube where double, just before emegrence at posterior end of double section. Shows epithelium wrapped around most of inner intestine, and muscles only connecting the folds in one place.

Fig. 3. Cross section through S-shaped portion of mid-intestine and hind-intestine, showing a layer of epithelium surrounding most of the inner folds of the tract.

Fig. 4. Longitudinal section showing emergence of anterior end of mid-intestine from near posterior end of same, where tract is double. Note epithelium pushed back by inner portion of intestine.

Fig. 5. Cross section of oesophagus much enlarged.

Figs. 6 and 7. Cross sections of open mid-intestine.

Fig. 8. Cross section of closed mid-intestine.

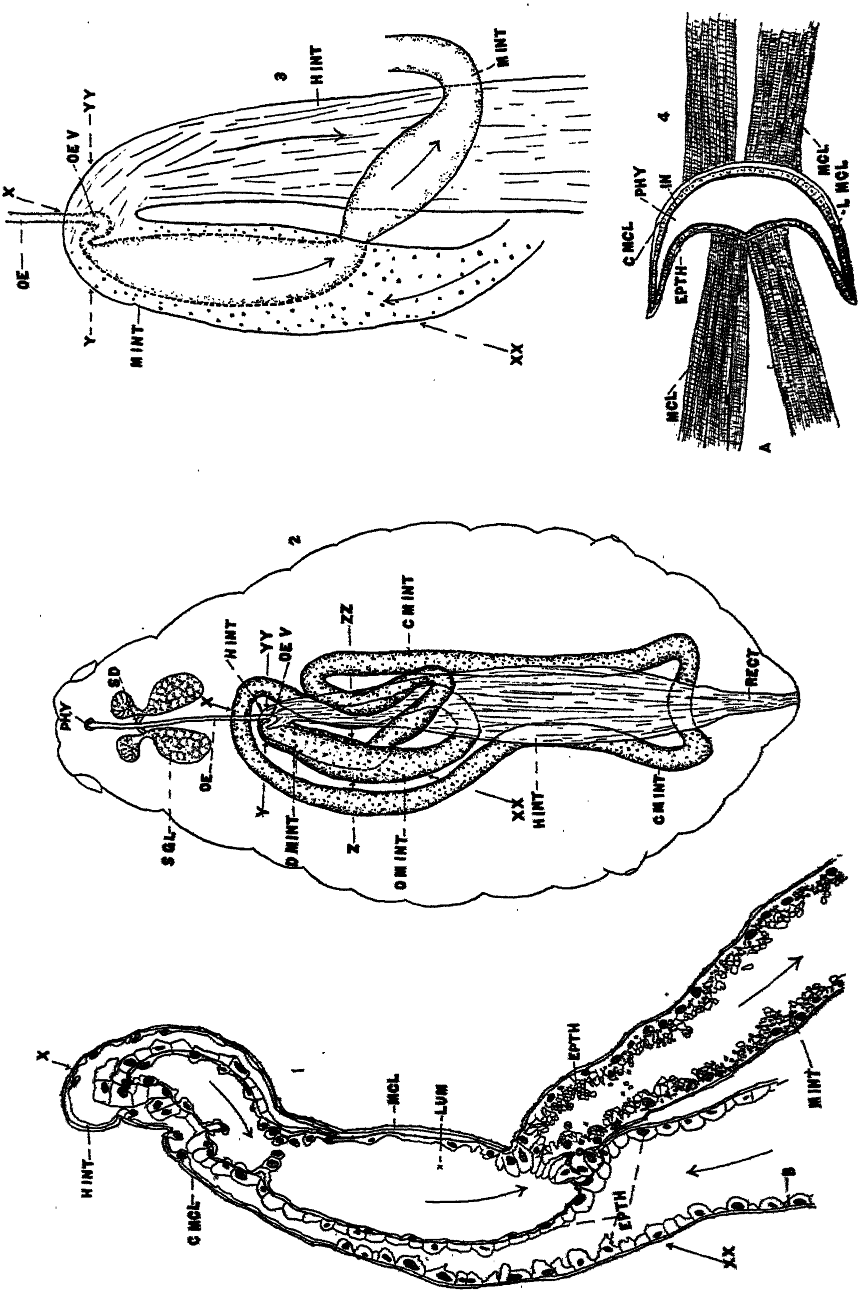
Fig. 9. Longitudinal section of posterior end of hind intestine showing end of sack-like portion, intestinal valve and rectum opening at anus.

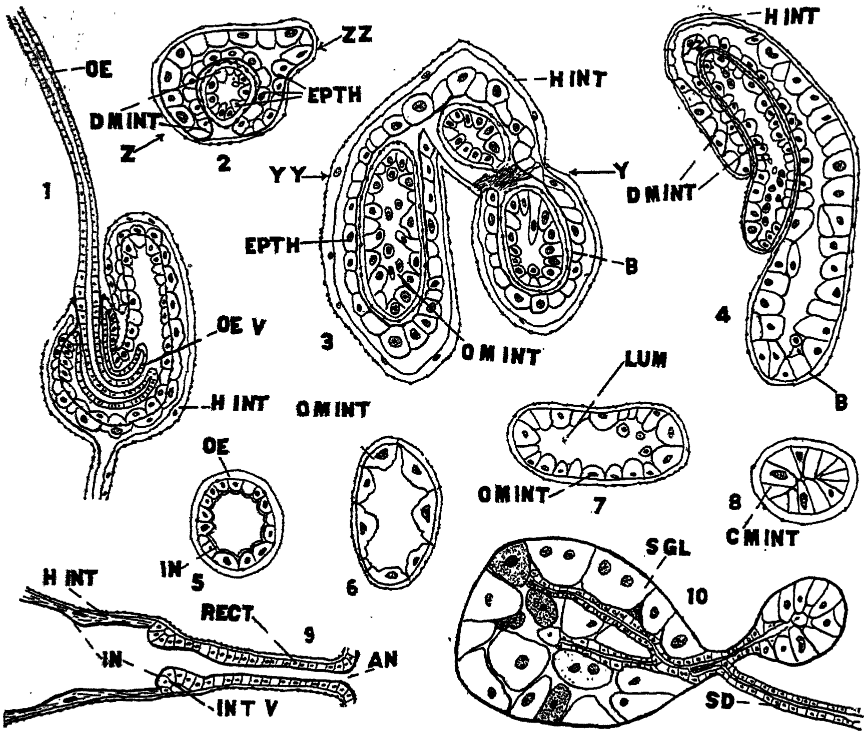
Fig. 10. Salivary glands and duct, showing the cells that stain at different intensities.

EXPLANATION OF ABBREVIATIONS.

A, anterior.
AN, anus.
ANT MCL, antennal muscle.
B, basement membrane.
C MCL, circular muscle.
C M INT, closed mid-intestine.
D M INT, double mid-intestine.
EPTH, epithelium.
H INT, hind-intestine.
IN, intima.
INT, intestinal valve.
LB, labium.
LM, labrum.
L MCL, longitudinal muscle.
LUM, lumen.
MCL, muscle.
MD, mandible.
MX, maxilla.
OE, oesophagus.
OE V, oesophageal valve.
O M INT, open mid-intestine.
PHY- pharynx.
PHY MCL, pharyngeal muscles.
RECT, rectum.
RO, "retort-shaped organs."
SD, salivary duct.
S L, salivary gland.
TEN, tentorium.

PLATE I


1
2
3
4
OE
X
OE V
YY
Y
H INT
M INT
XX
PHY
IN
MCL
L MCL
C MCL
EPTH
A
SD
S GL
RECT
ZZ
Z
C M INT
D M INT
O M INT
LUM
B


OE
D M INT
Z
ZZ
EPTH
1
2
YY
EPTH
H INT
Y
B
3
O M INT
D M INT
H INT
4
B
OE V
H INT
O M INT
OE
IN
5
6
LUM
O M INT
7
8
C M INT
H INT
RECT
9
IN
INT V
AN
SGL
10
SD

INSECT FOOD HABIT RATIOS IN DEATH VALLEY AND VICINITY.

HARRY B. WEISS
New Brunswick, N. J.

In "North American Fauna," No. 7, pp. 235–268, 1893, there appears a "Report on a Small Collection of Insects Made During the Death Valley Expedition," by C. V. Riley, with supplementary papers by Williston, Uhler and Bruner. Some 557 species are listed from such localities as San Bernardino County, Death Valley, Panamint Valley, Panamint Mountains, Argus Mountains, Coso Valley and Owens Valley. As the records of the collection offered tabulation possibilities, the activities of the insects reported, were reduced to certain food habit types, based on the predominating larval habits of the families, and expressed as ratios.

These ratios should be considered only as tentative in view of the fact that the collection upon which they are based is not as complete as it might have been, this being admitted in the report. Nevertheless as all of the important orders of insects were represented, it was thought that the species might possibly constitute a representative sample and so in spite of evident imperfections, the tabulations were made as matter of interest.

According to published accounts, the vegetation of the entire area in which the insects were collected is scant and descriptions of the whole territory abound in such terms as patches or scattered sparse growths of pinon and juniper trees, poorly supplied with grass and water, alkali flats, salt beds, bare mountains, hot springs, cacti, sand, yucca, western juniper, small-nut pines, beds of dry lakes, cones of extinct volcanoes and heaps of pumice. From such statements it can be assumed that the vegetation over the entire area, although sparse, is of the same general type.

In accordance with their family food habits, the 557 species can be grouped as follows:

Number of species	557
Phytophagous	37 per cent
Saprophagous	20 per cent
Harpactophagous	25 per cent
Parasitic	14 per cent
Pollen feeders, misc. spp	4 per cent

Unfortunately there are no food habit ratios from a similar area with which the above figures can be compared to serve as a check. They are unlike the sets of ratios present in areas embodying different types of vegetation as noted in the Proceedings of the Biological Society of Washington, Vol. 38, pp. 1–4, Table I and appear to exhibit a degree of variation similar to those found in areas which have uniform types of vegetation. (Proc. Biol. Soc. Wash. Vol. 38, pp. 1–4, Table II). In view of this, it is assumed that the food habit ratios of Death Valley and vicinity afford additional evidence for the support of the suggestion advanced in previous papers*, that in relatively small areas each with a uniform type of vegetation, the ratios between the various types of food habits, based on the species present, vary in accordance with the type of vegetation, if the numerical ratios between the species and the factors tending to reduce or change their numbers are considered as constant.

* Ohio Jour. Sci. Vol. XXIV, No. 2, pp. 100–106; Ent. News, Vol. XXXV, pp. 362–364; Proc. Biol. Soc. Wash. Vol. 38, pp. 1–4.

Date of Publication: October 20, 1925.

THE OHIO JOURNAL OF SCIENCE

VOL. XXV NOVEMBER, 1925 No. 6

A STUDY OF THE CESTODE PARASITES OF THE BLACK BASS IN OHIO, WITH SPECIAL REFERENCE TO THEIR LIFE HISTORY AND DISTRIBUTION.

RALPH V. BANGHAM,
College of Wooster

INTRODUCTION

These studies were first undertaken by the writer in the early summer of 1921 at the Lake Laboratory of Ohio State University at Put-in-Bay, Lake Erie, at the suggestion of Dr. R. C. Osburn, who had become interested in the larval stages of a proteocephalid found in the intestinal tract of young small-mouth bass (*Micropterus dolomieu*) just off their nest. At this time they measured 13–15 mm. The finding of large numbers of plerocercoids at such an early stage gave a clue as to the possible life history. Two possibilities were offered: either a direct infection or an infection through an intermediate host.

The earlier studies on the food of the young bass by E. L. Wickliff ('20) and Turner and Kraatz ('20) had shown that definite food cycles were present. Examinations were made of hundreds of these young bass, studying especially the stomach contents to discover the origin of the plerocercoid.

The studies also included an examination of the life history of two other cestode species found in the bass, studies of distribution of cestode species and on the degree of parasitism of bass in the state. In addition to the material collected during the summers of 1921 and 1922 many adult and young large- and small-mouth bass were examined from various sections of the state.

The methods were those ordinarily used for cestodes. La Rue ('14) gives the methods used in his study of Proteocephalidae and in the main these were followed.

Life History of Proteocephalus pearsei La Rue 1919

(Figs. 1, 2, 4, 14, 20.)

The larval proteocephalids found in the young small-mouth bass proved to be *P. pearsei.* The hosts given by La Rue for this species are *Perca flavescens* and *Ambolplites rupestris.* A very close series was obtained from the plerocercus to the adult.

In 1921 the bass left their nests the second week in June. Early in the season eighty per cent of the fish were infested. The average number of larvae per fish ranged from 4 to 12 on different days. In 1922 the infestation was much heavier. Nearly all were infested and early in the season 15 to 30 larvae were found in a fish. Later the infestation was much lighter.

Hosts.—These cestodes were found in small-mouth bass (*Micropterus dolomieu*), large-mouth bass (*M. salmoides*), rock bass (*Ambloplites rupestris*), blue gill (*Lepomis pallidus*), perch (*Perca flavescens*), and white bass (*Roccus chrysops*). In nearly every case they were found in young fish.

But little is known concerning the life history of the Proteocephalids. La Rue ('14) reviews the data and says concerning the intermediate hosts of the Protocephalids, "From the data presented by various workers it seems probable that the life history of the Proteocephalids is as follows: The eggs and some of the ripe proglottids bearing eggs are voided by the host into the water where they are eaten by some invertebrate, perhaps a worm, an insect larva, or a crustacean or possibly the eater is a vertebrate, fish, snake or amphibian of the same species as the host or different. If the invertebrate or vertebrate furnishes a suitable habitat for the development of the parasite it develops a plerocercoid about which the host produces a cyst, etc."

The work of Janicki and Rosen ('17) and Rosen ('18) offers some very important contributions to the life history of cestodes. Their papers were not seen until these studies were completed. Rosen was successful in solving the life histories of three cestode species by experimental methods. After studies with many groups of invertebrates under carefully controlled conditions, Rosen obtained positive results. He infected *Cyclops strenuus* and *Diaptomus* with the eggs of *Dibothriocephalus latus L.* Rosen says, "Three months after infection the larvae are still

living and fixed to the external wall of the intestine." The next stage of these studies was the infection of the fish which are second intermediate hosts of *D. latus*. Young trout were fed cyclops and Diaptomus which had been infected six weeks previously. The activated procercoids penetrate the muscular wall of the stomach and migrate to the liver or muscular tissues where the plerocercoid develops.

P. pearsei offered a favorable form for a life history study. The infection is obtained early while the food is made up of from 80% to 90% copepods. There was no other parasitism in the young bass at the first appearance of the infection. The copepods comprising the early food of the young bass consisted of: *Epischura lacustris*, *Diaptomus sicilis*, *Cyclops leuckarti*, *Cyclops serrulatus*, *Cyclops albidus* and *Cyclops prasinus*. *Cladocerans* and *ostracods* furnish a small part of the early fish food. The bass cease to eat copepods shortly after they reach 40 mm. After this time no plerocercoid stages were found.

The studies in 1921 yielded no definite results as to determination of an intermediate host. Early in the summer of 1922 a plerocercus was found in the body cavity of a species of *Cyclops*. The plerocercus was in the posterior part of the body cavity and its slow movements could be seen through the body wall. Further search resulted in finding many of these infested copepods. These were secured both in tow and by a careful examination of the stomach contents of the young bass. July 4, 1922, 12 of these infested copepods were found in tow at Put-in-Bay. In the stomach contents of a 20 mm. bass taken the same day 2 plerocercoids were seen emerging from a partially digested cyclops. Others were found shortly after emergence. Later *Epishura lacustris* was also found carrying this plerocercoid in the body cavity. Three individuals of this species were found that were infected.

The plerocercoid escapes as the copepod is digested and then passes to the intestine, where growth is rapid. See Figs. 1, 4, 14, for the early stages of the plerocercoid. Fig. 14 was drawn from a copepod taken in tow and was the earliest stage seen. Fig. 4 is a drawing of a somewhat later stage taken from cyclops found in stomach contents.

P. pearsei matures quickly, as shown by the early appearance of adult individuals, June 27, 1921, in an 18 mm. bass and in 1922 is indicated by the following records: On June 23, in a

17 mm. small-mouth bass there was found an individual with 10 proglottids. This cestode measured 4.9 mm. The scolex and one of the posterior segments are shown in Fig. 20. June 26, an 8 mm. individual was found with the posterior proglottids mature. This was found in a 17 mm. small-mouth bass. There were 25 larval *P. pearsei* in the intestine of this bass. July 2 in a 26 mm. small-mouth an individual 3.6 mm. long was found, with a neck 1.3 mm. long and 15 proglottids, the last two showing uterine pouches partially filled with eggs.

This cestode seems to be of but little economic importance, as most of them are lost the first season. There is but little correlation between degree of infestation and size of the fish.

Other Species.

Proteocephalus fluviatilis, new species.

(Figs. 8, 11, 13, 16, 18, 21, 22.)

The collections of this species were made from *Micropterus dolomieu* taken from southern Ohio streams. Individuals of this species were found in half of the bass examined. In most cases the infestation was heavy. This was the only cestode species found in this bass.

Diagnosis: Characters of the genus, worms of medium length, up to 180 mm., segmentation not very evident except in ripe proglottids, little wrinkling or folding. Head small and not set off from neck; suckers set well forward, close together; breadth of head, average 1.79 mm., 2.00 mm. maximum; length of head, average .089, 1.00 maximum. Diameter of suckers, average .079 mm. Fifth sucker muscular, functional, average .040 mm., in diameter .032–.045 and about .030 mm. deep. Neck 7, 5, 9, 10, 12, 16 mm. long by .5–.75 broad. First proglottid broader than long; .040 to .060 mm. long by .56 to .98 wide. Mature proglottid broader than long; 1.50 x .22–1.32 x .37–1.12 x .42–.90 x .50 mm. Ripe proglottids broader than long to quadrate, .90 x .55–.93 x .62–.63 x .64 mm. Genital sinus irregularly alternating in anterior one-third to one-half proglottid. Testes—two layers filling the space anterior to the ovary and between the vitellaria. Number of testes 73–98; average 84. Maximum diameter .084 x .068 mm., average .062 mm. x .046 mm. Vas deferens forming a compact coil extending on a line with the cirrus to the center of the proglottid. Cirrus pouch .160–.172–.212 long by .052–.060–.068 broad, average .185 x .055. Ratio of length of cirrus pouch to breadth of proglottid 2:7 to 2:9. Ductus ejaculatorius, 2–3 coils in cirrus pouch. Length of cirrus when protruded .058 to .098 by .03 mm. wide. Vagina anterior and dorsal cirrus pouch in most cases, extending straight

almost to the mid-line. Sphincter vaginæ weak. Receptaculum seminis anterior to the ovary. Vitellaria compact, follicules extending to anterior part of ovary, thinner in area of cirrus and vagina, but usually not absent. Ovary bilobed, connected by an arched mid-piece, thin and elongate in early proglottids, lobes thick and made up of separate parts in mature proglottids. Uterus with 3, 5, or 7 lateral outpocketings on either side.

Habitat: Intestine of *Micropterus dolomieu.*

The studies are based on about 100 stained and mounted specimens. Serial sections were useful for a part of the descriptions.

A large number of the worms were immature. The maximum length for the worms is 14, 16, and 18 cm. The segmentation is not marked, however, it is quite evident in ripe proglottids swollen with eggs. The worms have few folds or wrinkles and a weak muscular development. This is quite evident in the larval forms. The maximum breadth is 1.35–1.60 and is the greatest in the region of the mature proglottids.

The head (Fig. 16) is short and narrow. It is not set off from the neck. The suckers are well forward and are close together. The head measures .160–.20 mm. broad at the posterior margin of the suckers. The four suckers are placed very close together with sufficient room for the small fifth sucker at the apex. The suckers are nearly circular, muscular, cupped, and are from .064 to .098 mm. in diameter. The fifth sucker appears to be functional. It has a shallow cup and possesses musculature quite similar to the large suckers. It measures from .032–.045 in diameter by .026 to .034 mm. deep.

The length of the neck, as determined by measurement to the first segmentation visible in the stained specimen is 7–16 mm The neck is narrow, .2–.50 mm. wide. It is difficult to tell just where the neck ends, as the primordia of the reproductive organs appear early and there is a gradual increase in the development toward the posterior segments. The development of the reproductive organs is slower than in the other forms studied by the writer.

The early mature proglottids are much broader than long. In specimen 42: 8–1–21, 106 mm. long, in the 160th proglottid the breadth is 1.07 mm. and length .234 mm. The lobes of the ovary are separate, thin and elongate, each lobe 0.28 mm. broad by .040 mm. long. The testes are well developed and number 86. The vagina and cirrus sac, cirrus and ducts are

well developed. The vagina is widened at the anterior end. Fig. 21 shows a proglottid at a later stage than here described. The measurements of the 240th proglottid in this specimen (42) are 88 mm. by .45 mm. This proglottid is more nearly mature. The ovarian lobes are much thicker, closer together, compact, but still the separate divisions of the lobes can be distinguished. There are 311 proglottids in the specimen mentioned. Near the posterior end the reproductive organs are pushed aside by the uterine pouches. These fill almost completely the space between the follicles.

Fig. 22 is a drawing of a mature segment showing the early formation of the uterine pouches and Fig. 18 shows the conditions of a ripe proglottid filled with eggs. The ripe proglottids are more quadrate, measuring 84 x 70, 95 x 70, 90 x 80 mm.

The posterior proglottid is triangular in outline, the two lobes of the ovary crowded near the point of the triangle.

The genital pore is marginal and situated from the anterior third to near the middle of the proglottid, opening on a slight papilla in mature proglottids. The cirrus is elongate, ovoid, broadest at the inner end. The cirrus is straight, measuring .060–.100 in length when extended. The ductus ejaculatorius is thrown into from 1 to 3 coils in the cirrus sac. The vas deferens extends as a dense mass of coils to the middle of the proglottid. In ripe proglottids the coils of the vas deferens and vagina are pushed together in a small area by the uterine pouches.

The testes lie in two layers and number from 74–98. They measure from .056 x .040 to .084 x .068 mm.

The vagina usually opens slightly dorsal to the cirrus pouch and is anterior to it. It does not cross the cirrus pouch. In a few cases the vagina is ventral to the cirrus pouch. This is in specimens that were flattened while killing and fixing and it is probable that pressure altered the relations. The sphincter vaginae is very weak. It is located near the vaginal opening. The vagina curves gently to the mid-line and passes to near the ovary where it is thrown into a number of coils, both anterior and posterior to the arch connecting the ovarian lobes. The seminal receptacle is present as a pouch-like enlargement of the vagina anterior to the ovarian lobes. It was found only in earlier mature segments. The vitelline ducts and the circular shell gland could be seen in certain proglottids.

The vitellaria are follicular, forming a close mass at the lateral portions of the segment. The vitellaria are only partially interrupted by the cirrus sac and vagina. The vitellaria are situated .110 mm. from the margin in mature segments.

The uterus has few lateral outpocketings of large size. Most of these pockets are nearly straight and press against the vitellaria. They number 3, 5, and 7. The embryo measures .012–.014 mm. The three membranes were not measured.

Larval Stages.

(Fig. 8.)

The life history of this species has not yet been determined. The studies were made too late in the autumn of 1922 to determine an intermediate host. Young bass contained large numbers of these larval cestodes. It has not been possible to study these bass in the Ohio River drainage early in the year. The first young bass examined measured from 40 to 55 mm. These were from Anderson's Fork, Clinton County, and were obtained August 1, 1922. They contained many larval cestodes in the intestine, resembling the forms in the adult bass from the same stream. August 30, 1922, five specimens of small bass were obtained from the Olentangy River, Franklin County. All these were heavily infested with the small larval cestodes. September 19, 1922, four young small-mouth bass measuring 57, 62, 71 and 77 mm. were studied. There were from 20–60 larval cestodes in each of these fish. These cestodes formed a tangled mass in the intestine and occupied a larger mass than the digested food. See Fig. 8 for drawings of the scolex of these larval cestodes. Their musculature was weak. Their movements were slow and they broke apart easily.

Proteocephalus osburni, new species.

(Figs. 3, 15, 17, 19.)

This description is based on a single immature individual secured from a 57 mm. small-mouth bass taken by Dr. R. C. Osburn at the Akron Hatchery, August 28, 1922. There are so many characteristic differences and the structures are so definite that this individual is described as a new species. It is hoped that more material can be secured and a more adequate description given.

Diagnosis: Characters of the genus, size small, specimen immature, measuring 19 mm.; scolex (Figs. 3, 15) .140 broad by .060 mm. long; suckers deeply cupped, set well forward on the head. They measure .050 mm. in diameter. The fifth sucker is at the apex of the scolex and is .028 in diameter by .024 mm. deep. The neck is very long, 14 mm. to first trace of segmentation. The neck is .50–.60 mm. broad. There are but seven proglottids in this individual. The first measures .22 mm. long by .80 mm. broad, showing an abrupt widening from the neck. The next proglottid, (Fig. 19), shows well formed testes in a single layer. This proglottid measures .50 mm. in length and 1.00 mm. in breadth. The fourth proglottid shows the first indication of development of uterine pouches and measures .80 mm. in length by 1.25 mm. in breadth, (See Fig. 17). The seventh or end proglottid measures 1.10 mm. in length by .92 mm. in breadth. It is rounded at the posterior end.

The genital sinus is lateral and situated two-fifths to one-half the length of the proglottid from the anterior end. There is a genital papilla which is much more marked than in the case of *P. fluviatilis.* The vagina opens anterior to the cirrus. There is no evidence of a sphincter vaginae. The vagina is larger in diameter than in *P. pearsei.* The diameter is not constant. Near the vaginal opening the diameter is .016 to .020 mm.; the central portion near the inner end of the cirrus sac measures .007–.010 mm. Just anterior to the ovarian lobes the vagina is thrown into a loose coiled mass. This occupies a larger space than the coils in *P. fluviatilis.* The measurement of the vagina here is .016–.024 mm. and posterior to the straight connection of the ovarian lobes there are more coils of the vagina. The vaginal walls thicken and the diameter here is from .024 to .040 mm. No trace of a seminal recepticle was found.

The cirrus sac is V-shaped, the broadest part being near the genital opening. The cirrus sac is much larger than in *P. fluviatilis* and *P. pearsei.* It measures .320 x .112 mm.; .280 x .100 mm.; .360 x .80 mm. and .320 x .072 mm. in four proglottids. Both the cirrus and ductus ejaculatorius are coiled inside the cirrus sac, the latter being thrown into two to four loose coils. The cirrus is about twice the diameter of the ductus ejaculatorius. The extended cirrus was not seen. The vas deferens forms a narrow coiled portion extending to the center of the segment. The coiled portion is thicker at the center of the segment. The coils are loose and less in number than the other forms referred to by the writer.

The testes are in a single layer, closely pressed together between the vitellaria. They number from 50–60. They are modified by being pressed together. The average measurement is .068 x .052 mm. They vary from round to long ovoid form. The vitellaria are fine, densely packed and more numerous just anterior to the ovary. The vagina and cirrus sac completely interrupt the vitellaria.

The ovarian lobes are large, thick, heavy and irregular in outline and fill the posterior part of the segment except for a small area between the lobes. The mid-piece connecting the lobes is not arched in fully

mature segments. The lobes measure .310 mm. in maximum length and .468 mm. in maximum breadth.

The uterine pouches are formed in the fourth segment. They are small, straight and overlap. The counts of uterine pouches are 11–9, 10–8, 9–5, to 10–7, the lower number of pouches being on the side of the genital ducts. These pouches reach to the vitellaria in many cases.

Proteocephalus ambloplitis (Leidy).

(Figs. 5, 6, 7, 9, 10, 12.)

This species was found in the adult bass of Lake Erie. Twenty-five of sixty adult small-mouth bass taken within a few miles of Put-in-Bay were found infested. They had from 1–8 cestodes, the scolex usually fastened to the inside wall of the pyloric caeca and the strobila reaching into the intestine.

The larvae of this species are very abundant in many young fish. The larval cysts were found in very young fish attached to the mesenteries and in the visceral organs. They were often found in long thin-walled cysts confined to the peripheral portion of the liver. The worms show a slight activity within the cyst. The amount of infestation was not large in the young small-mouth bass. There was a much larger degree of infestation in the young large-mouth bass. Occasionally the liver and spleen were completely riddled by these parasites. In a few cases these plerocercoids were found inside the phyloric caeca.

Almost the same degree of infestation is found in the adult bass. In this case the cestodes were larger, often coiled about in the liver, reaching a length of 4–6 cm. No sexually mature individuals of *P. ambloplitis* were found during the first year's growth of bass.

The external and histological features of these plerocercoids have been well described by Cooper ('15). Cooper's data give records for 9 adult *M. dolomieu*. The present studies cover the examination of a large number of young large- and small-mouth bass. Several very early stages were found. The smallest of these plerocercoids were found in the mesenteries. Some specimens measured .16–.25 mm. in length, (see Figs. 5, 6). Some of these smaller forms were found imbedded in the muscular wall of the intestine of a large-mouth bass 26 mm. long. These young stages show the invaginated scolex in the process of formation. (Figs. 5, 6, 9, 10, 12). The four suckers seem to develop in the angles of a common area. The fifth sucker is the earliest to form, but remains vestigial.

Cooper ('15) failed to find an intermediate host for this form, but says concerning the life history, "Thus the evidence points to *P. ambloplitis* having at least two intermediate hosts, the first in some unknown species of arthropod, and the second either a different species of minnow, small perch or final host itself." My studies include the examination of younger bass than those of Cooper and offer additional evidence that this suggested life history is probably a correct one.

However, the plerocercus must reach the bass at a very early stage, soon after the bass come off the nest. The earliest forms found in the mesenteries are quite small and appear early in the life of the fish. These plerocerci must be carried by some of the copepods as the small-mouth bass scarcely ever eat amphipods. Also the liver and mesentery cysts are found in both large and small-mouth bass before they take amphipods. It must be an entomostracan and probably a copepod common in the diet of the bass at Put-in-Bay and the large-mouth bass along the harbors of the Ohio mainland. The young large-mouth bass show the heaviest infection. In these fish taken from West Harbor there were often 25–40 mesentery cysts and 6–10 liver cysts in a young fish measuring 25–37 mm. These young fish furnish the second intermediate host and development progresses rapidly. At this stage development is seen especially in the increase in size, muscular formation and in the further development of nervous and excretory systems.

In *Hyalella knickerbockeri* Bate, taken in tow at Put-in-Bay Harbor, encysted plerocerci were found. They were too large for *P. pearsei* plerocercoids, (see Fig. 7). In 12 *Hyalella* examined, 6 were infested with one or two of these plerocerci. These may be the plerocerci of *P. ambloplitis*. *Hyalella* is scarce at Put-in-Bay and not an important portion of the diet of the bass. At East and West Harbors several hundred of these amphipods were examined, but no plerocerci were found. If *Hyalella* is an invertebrate host for *P. ambloplitis*, there must also be another form, as these amphipods are too scarce to account for the degree of infestation and often young bass have the cysts before *Hyalella* is an article of diet.

DISTRIBUTION OF CESTODES.

La Rue ('14) gives a summary of hosts reported and localities for the *proteocephalidae* in amphibians, reptiles, and fish. *P. ambloplitis* is the only form reported for the bass. *P. ambloplitis* is known only from waters which drain into the St. Lawrence and Red River of the North, according to La Rue.

Prof. H. B. Ward (La Rue '14), examined the proper host species in the Illinois river, but the cestode was not found.

It was not found as adult in any of the 200 adult small-mouth bass examined from the Olentangy River, Little Miami River, Caesar's Creek, Paint Creek and other streams of the Ohio River drainage. In adult large and small-mouth bass examined from Newtown, London and Akron State Hatcheries, no adult *P. ambloplitis* were found. In a few cases larval cestodes of this species were found encysted in the livers. The probability is that these were in bass introduced from Lake Erie. This was known to be the case for those examined at one of the hatcheries. It seems likely that this cestode would be introduced in streams where adult bass from Lake Erie had been placed, but perhaps the proper invertebrate host is not present. The only record for finding the adult *P. ambloplitis* in the Ohio River drainage was at Lake Chautauqua, N. Y., where two adult bass had a heavy infestation. Many others showed only larval cysts in the viscera.

Proteocephalus fluviatilis.

This cestode was found only in *M. dolomieu* in southern Ohio streams. No other hosts were found for this species.

Proteocephalus pearsei.

This form was confined to the younger fish in Lake Erie and the Lake drainage. In a few cases this cestode was found in older fish. None were found in the Ohio River drainage.

Proteocephalus exiguus.

This form was not found in Ohio, but was found in *M. dolomieu* in material collected by Needham and Sibly, at Lake George, N. Y.

Pseudophyllidean Cestodes.

Cooper ('18) revised the family describing the forms belonging to this group and including several new species from North American fish. Two species of larval cestodes belonging to this group were found in small-mouth bass. They were found only in a few cases and perhaps represent chance infestation.

Triaenophorus nodulosus (Pallas).

Two specimens of this species were discovered both encysted in the liver. They were coiled in an oval cyst near the periphery of the organ. One was found in a young small-mouth bass and the other in an adult of 27 cm.

Bothriocephalus claviceps (Goeze 1784).

Adult specimens of this cestode were found in the upper intestine of a rock bass (*Ambloplitis rupestris*). Larval forms were found in four small-mouth bass; two from 10 cm. individuals secured near Put-in-Bay, one from an 11 cm. small-mouth from Maumee Bay, and one from an adult small-mouth taken from Anderson's Creek, Clinton County, Ohio.

Summary.

1. The studies include examination of a large number of adult and young specimens of large and small-mouth bass from many sections of Ohio and from Lake Erie. In the small-mouth bass seven species of cestodes were found. Two of these were new species and six had not been previously reported for the bass. In large-mouth bass two species of cestodes were found.

2. By intensive study of young bass from the time they leave their nests it is shown that certain cestodes are obtained early, while the food is chiefly copepods.

3. The factors involved in a life history study are date of infection, age of fish, and food of fish at the time.

4. The life history of one proteocephalid (*P. pearsei*) was demonstrated. The intermediate host may be either of two species of copepods, *Epishura lacustrius* or a small species of *Cyclops*.

5. The studies on the early larval stages of *P. fluviatilis* indicatea life history similar to *P. pearsei*.

6. Evidence points to two intermediate hosts for *P. ambloplitis;* one an *Entomostracan* and the other a minnow or young fish of the same species as the host of the adult *P. ambloplitis*.

7. There are different cestode parasites in the bass in Lake Erie and its drainage system from those in the Ohio River drainage.

BIBLIOGRAPHY.

COOPER, A. R. (1915 a).
Contributions to the Life History of Proteocephalus ambloplitis Leidy. Contr. Canad. Bio. Fac. 11, Fresh Water Fish and Lake Bio. p. 177–194, Pl. XIX, XX, XXI.
(1918.) North American Pseudophyllidean Cestodes from Fishes. III. Biol. Mono. Vol. IV. No. 4, p. 294–541, 13 pl.

JANICKI, C. ET ROSEN, F. (1917.)
Le cycle evolutif du Dibothriocephalus latus L. Recherches experimentales et observations. Bulletin de la societe Neuchateloise des Sci. Nat. t. xiii, p. 19–53.

LA RUE, G. R. (1914).
A Revision of the Cestode Family Proteocephalidae. Ill. Bio. Mono. Vol. 1, Nos. 1 and 2, p. 1–350, 16 pl.
(1919.) A New Species of Tapeworm of the Genus Proteocephalus from the perch and rock bass. Occas. Papers, Museum of Zool., Uni. of Mich., Publ. 67, p. 1–9, 1 pl.

ROSEN, F. (1918).
Recherches sur le Developpement des Cestodes. I. Le Cycle evolutif de Bothriocephalus. Bull. de la soc. Neuchateloise Sci. Nat. T. XLIII, p. 241–300. Recherches sur le Developpment des Cestodes II. Le Cycle evolutif de la Ligula. Bull. de la Soc. Neuchateloise des Sci. Nat. T. XLV.

TURNER, C. L. and KRAATZ, W. C., (1920).
Food of Young Large-Mouth Black Bass in Some Ohio Waters. Trans. Am. Fish. Soc. Vol. L, p. 372–380.

WICKLIFF, E. L. (1920).
Food of Young Small-mouth Black Bass in Lake Erie, Trans. Am. Fish. Soc. Vol. L. p. 364–371.

EXPLANATION OF FIGURES.

PLATE I.

All drawings have been with the aid of the camera lucida and the scale given with each.

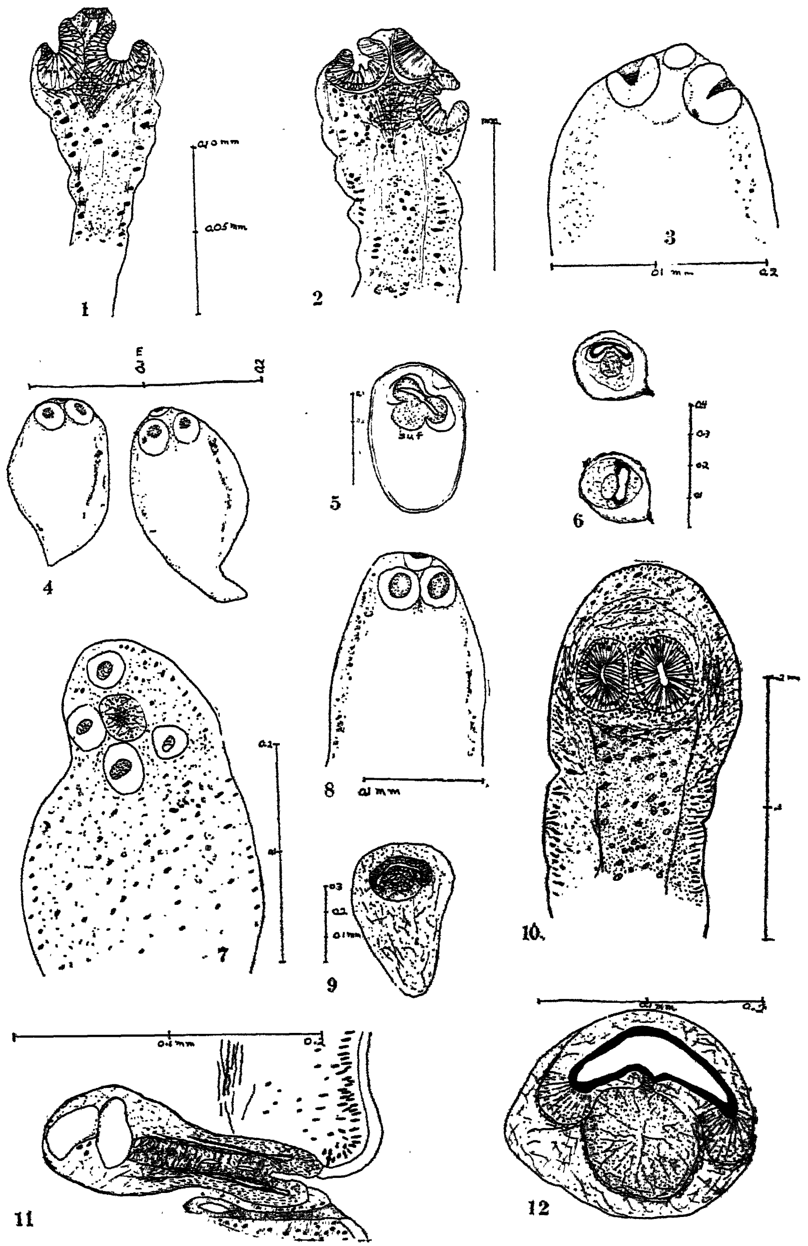
Abbreviations used:

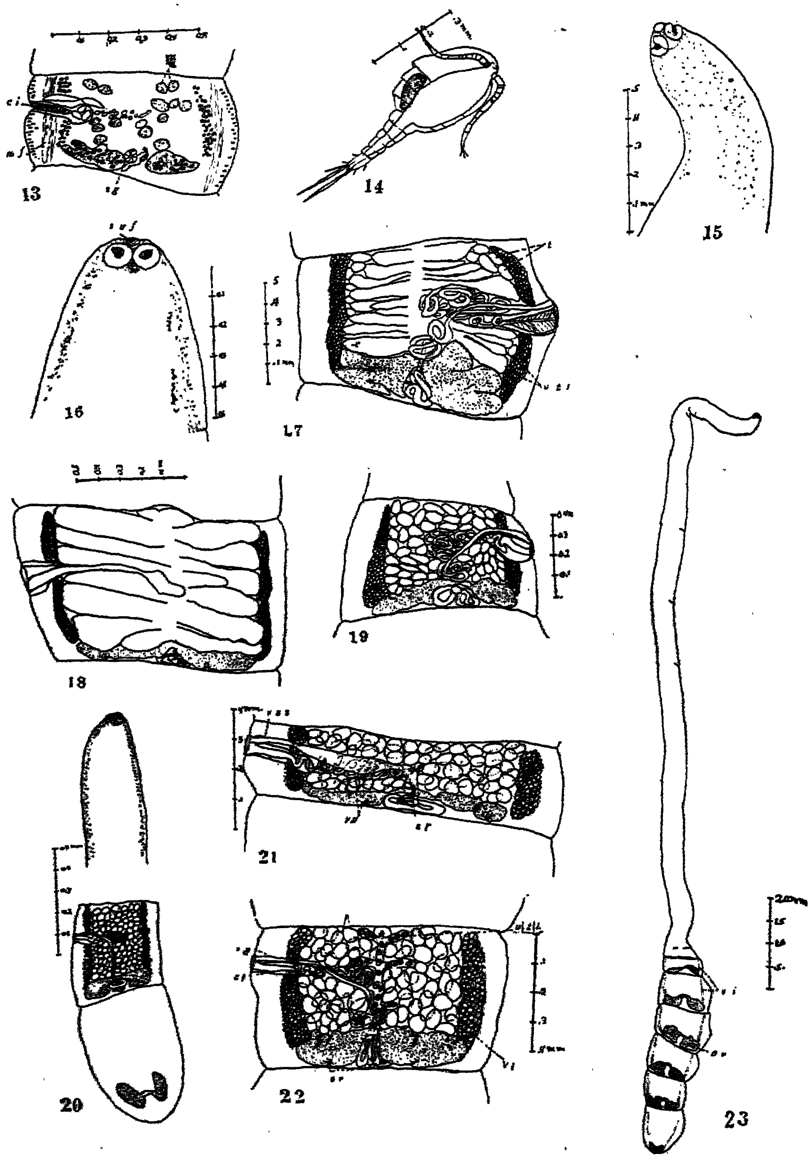
Ci—Cirrus.
Mf.—Muscle fibers.
Ov—Ovary.
Sg.—Shell gland.
Sr.—Receptaculum seminis.
Suf.—Fifth Sucker.
T—Testes.
Utl.—Lateral uterine pouches.
Va.—Vagina.
Vas—Sphincter vaginae.
Vd—Vas deferens.
Vi—Vitellaria.

Fig. 1. Proteoce.halus pearsei, head of larva, longitudinal section showing structure of suckers, etc.
Fig. 2. Proteocephalus pearsei, head of adult, longitudinal section.
Fig. 3. Proteocephalus osburni, head, one of four suckers shown by dotted line ventral, not indicated, adult, type specimen.
Fig. 4. Proteocephalus pearsei, larvae, the smaller taken from cyclops, the other from the stomach contents of 15 mm. small-mouth bass, 6-20-22.
Fig. 5. Proteocephalus ambloplitis, plerocercoid from the liver cyst showing formation of suckers.
Fig. 6. Proteocephalus ambloplitis, early plerocercoids from mesentery cysts.
Fig. 7. Plerocercoid taken from body cavity of Hyalella knickerbockeri.
Fig. 8. Proteocephalus fluviatilis, head toto, larval.
Fig. 9. Proteocephalus ambloplitis, plerocoid from mesentery. cyst.
Fig. 10. Proteocephalus ambloplitis, longitudinal section of plerocercoid from intestine of young large-mouth bass to show details of suckers etc., section not through center of plerocercus.
Fig. 11. Proteocephalus fluviatilis, cirrus, cirrus pouch, and portion of vagina. Note.—The vagina is dorsal to the cirrus sac. This drawing is inverted.
Fig. 12. Proteocephalus ambloplitis, portion to show details of developing suckers and vestigial fifth sucker of plerocercus.

PLATE II.

Fig. 13. Proteocephalus fluviatilis. Section showing cirrus, portions of vagina and ovarian lobes.
Fig. 14. Cyclops prasinus with plerocercus in body cavity, appendages removed from cyclops.
Fig. 15. Proteocephalus osburni, head, toto.
Fig. 16. Proteocephalus fluviatilis; head, adult toto.
Fig. 17. Proteocephalus osburni, ripe prolgottid, toto.
Fig. 18. Proteocephalus fluviatilis, ripe proglottid toto showing filled uterine pouches, type specimen.
Fig. 19. Proteocephalus osburni, early mature proglottid toto.
Fig. 20. Proteocephalus pearsei, early mature individual from 17mm. small-mouth bass collected 6-22-22.
Fig. 21. Proteocephalus fluviatilis, toto early mature proglottid showing testes and relations of cirrus and vagina.
Fig. 22. Proteocephalus fluviatilis late mature proglottid showing formation of lateral uterine pouches and more typical vagina than in preceding stage.




13
14
15
16
17
18
19
20
21
22
23

THE CARROT FAMILY IN OHIO.*

NELLIE F. HENDERSON.

AMMIACEAE, CARROT FAMILY.

Herbs with alternate, simple or compound, frequently dissected leaves, often with sheathing or dilated petioles, and solid or hollow often grooved stems. Inflorescence a simple or compound umbel with or without involucre and involucels, rarely a head, usually with numerous flowers. Flowers small, commonly white, yellow, or greenish, or occasionally of other colors; usually bisporangiate, epigynous, tetracyclic, choripetalous, actinomorphic, or the marginal ones slightly zygomorphic; andrecium, calyx and corolla pentamerous, the calyx commonly minute or suppressed; gynecium of two carpels. Ovulary bilocular, styles two, filiform, distinct, straight or recurved after flowering, often borne on a conic or depressed stylopodium; ovules one in each cavity, pendulous, anatropous, with a single integument. Ripe fruit a dry schizocarp, often flattened dorsally or laterally, splitting into the two-seeded carpels (mericarps) and usually supported on the summit of a slender axis (carpophore). Carpels or mericarps each with 5 primary ribs in their pericarps or rarely ribless, and in some genera with 4 additional secondary ones, the ribs of some of them often winged. Pericarp membraneous or corky thickened, usually containing oil-tubes under or between the ribs and on the commisural sides, sometimes irregularly scattered, and sometimes none.

PHYLETIC SYNOPSIS.

I. Mericarps with woody fibrous endocarp without a carpophore.
(Hydrocotylatae) (Hydrocotylae) Hydrocotyle.

II. Mericarps with a soft parenchymatous endocarp; exocarp seldom smooth; style long with a capital stigma, surrounded at the base by a ring-like stylopodium; oil-tubes various. (Saniculatae) (Saniculeae).
- A. Fruit ribless, flowers scaly, densely capitate.
  Eryngium.
- B. Fruit ribless, flowers not scaly, ours having fruit with dense prickles; umblets globose.
  Sanicula.

III. Mericarps with soft parenchymatous endocarp, occasionally hardened by a sub-epidermal layer into a nut-like fruit. Style at the summit of the stylopodium. Oil-tubes developed laterally in the young fruit, later variously developed. (Ammiatae).
- A. Fruit with secondary ribs most prominent, winged or barbed with prickles, ribs slender and bristly. (Dauceae). Daucus, Torilis.
- B. Fruit with primary ribs only. Fruit linear or linear-oblong, several times longer than wide. (Scandicineae) Deringa, Chaerophyllum, Washingtonia, Scandix.

---

* Papers from the Department of Botany, the Ohio State University, No. 161.

C. Fruit with primary ribs only, fruit oblong to ovoid or globose, not more than twice as long as wide. (Ammieae).
   1. Fruit nearly terete.
      a. Flowers yellow.
         Thaspium.
      b. Flowers white.
         Ligusticum, Coriandrum, Aethusa.
   2. Fruit flattened dorsally.
      a. Flowers yellow.
         Pastinaca, Anethum.
      b. Flowers white.
         Heracleum, Angelica, Conoselinum, Oxypolis.
   3. Fruit flattened laterally.
      a. Flowers yellow.
         Zizia, Taenida, Apium, Foeniculum, Bupleurum.
      b. Flowers white.
         Sium, Aegopodium, Pimpinella, Cicuta, Conium, Eulopus, Carum, Celeri, Erigenia.

Key to the Genera.

1. All leaves simple....................2
1. Some or all leaves compound or dissected....................3
2. Leaves linear, toothed; flowers white or pink in a head.......*Eryngium* (2)
2. Leaves orbicular, perfoliate; flowers yellow...............*Bupleurum* (24)
2. Leaves reniform or orbicular, crenate; flowers white.......*Hydrocotyle* (1)
3. Umblets globose; fruit with hooked bristles.................*Sanicula* (3)
3. Umblets flat, or somewhat flat, or convex; fruit bristly or smooth.........4
4. Leaves once compounded; flowers white....................5
4. Leaves decompound, flowers white or yellow; or once compounded with flowers yellow....................8
5. Leaves trifoliate....................6
5. Leaves pinnately compound....................7
6. No involucels, irregular loose umbels.......................*Deringa* (6)
6. Numerous linear bracts in involucels; 5–20 umblets in umbel rays stout. *Heracleum* (16)
7. Leaflets lanceolate, serrate; basal and lower leaves pinnatifid....*Sium* (26)
7. Leaflets lanceolate or entire, or with very few teeth in our species...... *Oxypolis* (19)
8. Flowers yellow or occasionally dark purple....................9
8. Flowers white, greenish-white or pinkish....................15
9. Leaf segments linear....................10
9. Leaf segments broad, lanceolate to ovate or broader....................11
10. Pedicels ⅛ in. or less long, fruit terete or nearly so.......*Foeniculum* (23)
10. Pedicels ⅛–⅜ in. long, fruit flattened dorsally.................*Anethum* (15)
11. Leaflets ovate, entire....................*Taenida* (21)
11. Leaflets serrate, crenate, or incised....................12
12. Stem leaves pinnately compound, large, leaflets broad, doubly cleft or serrate; stem prominently grooved......................*Pastinaca* (14)
12. Stem leaves ternate, basal leaves simple or compound....................13
13. Uppermost leaves linear-oblong, entire; involucre of 2–4 linear bracts.... *Apium* (22)
13. None of the leaves linear-oblong, involucre none or of small bracts.......14
14. All of the flowers pediceled; fruit nearly terete............*Thaspium* (10)
14. Central flower of each umblet sessile; fruit flattened laterally......*Zizia* (20)
15. Low or slender decumbent, nearly acaulescent; leaves finely divided; umbels of 1–6 umblets....................16
15. Tall and erect; embels of usually more than 6 many-flowered umblets......18
16. Scapose, subtending leaf involucrate to umbel; umbel of 1–4 umblets.... *Erigenia* (33)
16. Branched, involucre wanting or of few small bracts....................17

17. Bracts of involucre notched at tip; fruit linear, flattened.........*Scandix* (9)
17. Bracts of involucre ovate-lanceolate; carpels 5-angled...*Chærophyllum* (7)
18. Involucre leafy; umbel 2–4 in. broad, concave in fruit, central flower often purple, ovulary bristly.................................*Daucus* (4)
18. Involucre inconspicuous or none..19
19. Leaf segments ovate or ovate-lanceolate, serrate or incised...............20
19. Leaves finely dissected into linear or narrow segments...................25
20. Umbels loose, 1–7 umblets; leaflets cut and deeply incised.................21
20. Umbels dense, umblets more than 7, usually numerous......................22
21. Unvolucels persistent, umbels very loose, peduncles long...*Washingtonia* (8)
21. Involucres and involucels small or none; umbels compact, opposite leaves. *Celeri* (32)
22. Involucels of numerous bracts...23
22. Involucels of several small bracts or wanting.............................24
23. Calyx-teeth acute; purple lines on stem; aquatic................*Cicuta* (29)
23. Calyx-teeth obsolete; stem leaves nearly sessile; not aquatic..*Ligusticum* (11)
24. Stylopodium depressed; divisions of the leaves pinnate, upper leaves reduced with large sheathing bases.......................*Angelica* (17)
24. Stylopodium conic; leaves ternate or biternate, ultimate segments stalked...*Aegopodium* (27)
25. Few long linear leaflets; aquatic plants.......................*Cicuta* (29)
25. Stem leaves dissected into many filiform divisions; plants not aquatic.....26
26. No involucre; basal leaves ovate or orbicular, incised, pinnate leaves.....27
26. Involucres present but may be early deciduous; all leaves divided into linear segments..28
27. Involucels of few narrow bracts, deciduous; basal leaf segments deeply incised...*Coriandrum* (12)
27. No involucels; basal leaf segments ovate, dentate. ....*Pimpinella* (29)
28. Pubescent; ovulary with dense bristles.......................*Torilis* (5)
28. Glabrous; ovulary smooth...29
29. Bracts of involucels setaceous, turned downward to one side; stylopodium broad and thick...*Aethuso* (13)
29. Bracts of involucels when present not turned to one side; stylopodium none, conic or depressed...30
30. Calyx-teeth prominent; leaves ternately compound, segments linear...... *Eulophus* (30)
30. Calyx-teeth minute or obsolete...31
31. Calyx-teeth minute; leaflets pinnatisected into linear filiform segments.. *Carum* (31)
31. Calyx-teeth obsolete; leaves ternate or broad, segments not filiform......32
32. Wavy-ribbed; involucres and involucels of ovate-acuminate bracts; carpels nearly terete...*Conium* (25)
32. Ribs of carpels not wavy; involucre none or of few short bracts; involucels of narrow acuminate bracts; fruit flattened dorsally......*Conioselium* (18)

Description of Species.

1. *Hydrocótyle* L.

Prostrate herbs commonly rooting at the nodes. Leaves simple, palmately veined. Bracts of the involucre few or none. Flowers white. Calyx-teeth minute or obsolete. Fruit laterally compressed broader than long, no oil-tubes, but having a layer of oil-bearing tissue beneath the epidermis.

1. Leaves orvicular, peltate; pedicels slender..................*H. umbellata*
1. Leaves orbicular or reniform, not peltate.................................2
2. Flowers umbellate, umbels nearly sessile....................*H. americana*
2. Umbels capitate, peduncled...................................*H. rotundifolia*

1. *Hydrocotyle umbellàta* L. Many-flowered Marsh-Pennywort.

Perennial with glabrous creeping stem, subterranean branches tuberous; leaves simple, orbicular, crenate, peltate, petioles slender, 1-6 in. long; umbels long-peduncled, usually simple, pedicels slender; fruit strongly notched. In swamps and low ground. June-September. Portage and Stark counties.

2. *Hydrocotyle americàna* L. American Marsh-Pennywort.

Stems slender, creeping, propagating by stolons; leaves thin, reniform, crenate, not peltate, petioles short, seldom over 2 in. long; umbels nearly sessile, axillary, 1 to 5-flowered. In wet soil, June-September. Cuyahoga, Summit, Wayne, Stark.

3. *Hydrocotyle rotundifòlia* Roxb. Asiatic Penny-Wort.

Slender, tufted, creeping perennial; leaves reniform-orbicular; petioles slender; peduncles nearly as long as the petioles. Escaped to lawns from green-houses. Native of Asia. Summer. No specimens.

2. *Eryngium* (Tourn.) L.

Perennial herbs with spiny toothed leaves, lobed, dentate or entire; white or blue flowers in a head subtended by bracts; calyx-teeth rigid, acute, pungent; petals erect; disk expanded; fruit scaly or rough, somewhat flattened laterally, ribs nearly obsolete, oil-tubes, 5.

1. *Eryngium aquáticum* L. Button Snakeroot.

Stout glabrous perennial, 2 to 6 ft. tall; leaves mostly clasping, parallel veined, margins with bristly teeth, lower ones sometimes 3 ft. by 1½ in., upper ones smaller; heads globose-ovoid. By ponds and streams. June-September. Wyandot, Erie.

3. *Sanicula* L.

Perennial or biennial herbs with palmately 3 to 7-divided leaves, and globose umblets of small flowers; stems glabrous; umbels of few umblets; calyx-lobes usually persistent; petals obovate, inflexed; disk flat; carpels not ribbed; oil-tubes usually 5; fruit sub-globose with hooked bristles.

1. Petals and anthers yellow, calyx-lobes ovate, obtuse........... *S. gregaria*
1. Petals white...2
2. Petals much longer than the obtuse, ovate calyx-lobes........ *S. marylandica*
2. Petals somewhat shorter than the linear-lanceolate, acute calyx-lobes.... *S. canadensis*
2. Petals about half as long as the linear, rigid, in-curved calyx-lobes.. *S. trifoliata*

1. *Sanicula gregària* Bickn. Clustered Snakeroot.

Rather weak slender stemmed perennials with stems usually clustered and umbellate branched, 1 to 3 ft. high; leaves thin, light green, 5-foliate, segments stalked, obovate, acuminate, sharply serrate with bristle tipped teeth, involucral leaves foliaceous; some staminate flowers in separate heads, petals yellowish, much longer than the calyx-lobes, anthers yellow; fruit with weak bristles and long, persistent, recurved styles. Rich woods. May-July. Rather general.

2. *Sànicula marylândica* L. Black Snakeroot.

Glabrous perennials, 1½ to 2 ft. high, topped by 2 to 4-rayed, long-peduncled, compound umbel; leaves few, those near the base long-petioled, upper ones nearly sessile, bluish-green, 5 to 7-parted, irregularly serrate or incised; involucral leaves 3-parted, much smaller; staminate flowers often in separate heads, petals greenish-white, little longer than the calyx-lobes, anthers white; fruit sessile, covered by stout bristles, the long recurved styles persistent. In rich woods. May-August. General.

3. *Sanicula canadênsis* L. Short-styled Snakeroot.

Widely branched biennial, 1 to 4 ft. high, leafy, branches forked; all leaves petioled, 3 to 5-divided, segments to 3½ in. long, dull green, involucral leaves small, involucels bract-like; staminate flowers few, never in separate heads, petals white, shorter than the calyx-lobes; fruit nearly sessile, sub-globose, styles shorter than the bristles. In dry woods. May-August. General and abundant.

4. *Sanicula trifoliàta* Bickn. Large-fruited Snakeroot.

Slender, alternate-branched biennial, 1 to 2½ ft. tall; leaves thin, bright green, slender-petioled, 3-parted, lateral segments often cleft, segments stalked, broadly ovate, coarsely doubly serrate; petals white, about half as long as the calyx-lobes; fruit ovoid, styles shorter than the bristles. Rich hilly woods. June-August. Southern and eastern part of the state to Geauga, Morrow and Preble Counties.

4. *Daùcus* (Tourn.) L.

Involucre foliaceous, pinnately parted; involucels of numerous bracts; calyx-teeth obsolete; umblets many-flowered; ribs slender; petals obovate, inflexed at the tip, those of the outer flowers often 2-lobed; oil-tubes solitary under the secondary ribs.

1. *Daucus caròta* L. Queen Anne's Lace.

Bristly-stemmed biennial, 1 to 3 ft. tall, from a fleshy conic root; leaves 2 to 3-pinnate, segments lanceolate, pennatifid, the upper ones similar, but smaller; umbels 2 to 4 in. broad, very concave in fruit; flowers white, central one often purple; fruit bristly on wings. A common weed in waste places, pastures, and roadsides. The origin of the cultivated carrot and the only one of the family which is regarded for its beauty. Naturalized from Europe. June-September. General and abundant.

5. *Tórilis* Adans.

Involucre of few bracts or wanting; involucels of several narrow bracts; calyx-teeth triangular, persistent; petals inflexed at tip; stylopodium thick, conic; fruit flattened laterally, bristly.

1. Umbels sessile or short stalked.......................................*T. nodosa*
1. Umbels long-peduncled, compound.............................*T. anthriscus*

1. *Torilis nodòsa* (L.) Gaertn. Knotted Hedge-Parsley.

Decumbent, spreading, hispid or pubescent annuals, branched at base, branches 6 to 12 in. long; leaves bi-pinnate, segments linear-oblong; umbels sessile or short-stalked opposite the leaves at the nodes, capitate; flowers white; fruit sessile, ovoid, with long prickles often confined to one side. In waste places. May-August. No specimens.

2. *Torilis anthrìscus* (L.) Gml. Erect Hedge-Parsley.

Erect, slender, hispid annual, 2 to 3 ft. tall; leaves bi-pinnate, upper may be simply pinnate, segments may be lanceolate, dentate, or pinnatifid; umbels slender-peduncled, 1 to 2 in. long; flowers white; fruit ovoid with dense bristles. Adventive from Europe. In waste places. July-September. Hamilton Co.

6. *Dêringa* Adans.

Irregular umbels of white flowers; no involucres or involucels; calyx-teeth obsolete; stylopodium conic; fruit laterally compressed, glabrous; ribs nearly equal; oil-tubes solitary in intervals and beneath ribs.

1. *Deringa canadênsis* (L.) Ktz. Honewort.

Erect, rather slender, freely branching perennial, glabrous, 8 in. to 3 ft. tall; lower and basal leaves long-petioled, 3-parted, segments ovate, serrate, incised, or lobed, 1 to 4 in. long; upper ones nearly sessile, uppermost a margined, incised stalk; umbels of 4 to 10 umblets; fruit glabrous, one-eighth to one-fourth in. long, pointed at both ends. In open woods. May-August. General.

7. *Chaerophyllum* (Tourn.) L.

Small umbels of white flowers; involucre none, or of 1 or 2 bracts; involucels of many linear bracts; calyx-teeth obsolete; stylopodium conic, small; fruit oblong, flattened laterally, ribs equal, oil-tubes solitary in the intervals.

1. *Chaerophyllum procùmbens* (L.) Crantz. Spreading Chervil.

Much branched, slender, spreading annual, 6 to 20 in. tall; decompound leaves, segments ovate, pinnatifid, lower ones slender petioled, upper ones nearly sessile; umbels few rayed, few flowers in an umblet; fruit glabrous or slightly pubescent, one-fourth to one-half inch long, contracted, notched at the base. In moist ground. April-June. General.

8. *Washingtònia* Raf.

Aromatic clustered roots; umbels few rayed; involucres and involucels small or none; calyx-teeth obsolete; fruit elongated, ribs acute, nearly equal, oil-tubes obsolete.

1. Stems and leaves pubescent .... *W. claytoni*
1. Glabrous or only slightly pubescent at the nodes .... *W. longistylis*

1. *Washingtonia clàytoni* (Mx.) Britt. Downy or Wooly Sweet-Cicely.

Erect perennials, downy, especially when young, ½ to 3 ft. tall, branched above, stems often stained a dull red; lower leaves ternately decompound, large, often 1 ft. broad, long petioled, the upper ones less compound, nearly sessile; segments ovate, incised, dentate; umbels irregular, long-peduncled, few flowers in umblet opposite leaves; flowers small, white; fruit bristly, ½ in. long, constricted at the base. In woods. General.

2. *Washingtonia longístylis* (Torr.) Britt. Anise-root.

Similar to the preceding species, but glabrous when mature, except at the nodes; leaflets less cleft; fruit about 1 inch long. In woods. May-June. General.

9. *Scándix* (Tourn.) L.

Involucels none or occasionally one bract; petals usually unequal; stylopodium short; fruit linear, flattened laterally, beak much longer than fruit; primary ribs prominent, secondary ribs wanting, oil-tubes solitary or wanting.

1. *Scandix pectenvéneris* L. Venus' Comb.

Slender annual, 6 to 18 in. tall, sparingly pubescent, branched, ascending; leaflets pinnatisected, lobes acute; no involucre, bracts of the involucels notched at the tip; umbels compound; flowers nearly sessile in the umblets; beak of fruit 1½ to 2½ in. long, edged with stiff hairs. Waste places. Fugitive from Eurasia. May-August. Lake Co.

10. *Tháspium* Nutt.

Involucre none or of few small bracts; involucels of several small bracts; all flowers pediceled; calyx-teeth conspicuous, acute; no stylopodium; styles long; fruit ovoid, only slightly flattened dorsally, some or all ribs winged, oil-tubes solitary in intervals.

1. Glabrous, leaves mostly ternate, 1–2 ft. tall..................*T. trifoliatum*
1. More or less pubescent, especially at nodes, biternate, 2–4 ft. tall............2
2. Leaf segments ovate, acute, serrate, or cleft....................*T. barbinode*
2. Leaf segments pinnatifid into linear-oblong lobes............*T. pinnatifidum*

1. *Thaspium trifoliàtum* (L.) Britt. Purple Meadow-Parsnip.

Erect glabrous perennial, 1 to 2 ft. tall; basal leaves long-petioled, sometimes simple, cordate, serrate; stem leaves short-petioled, ternate or biternate, segments ovate-lanceolate, crenate, thick; umbels small; flowers yellow or purple; fruit ovoid-globose, all ribs winged. In woods and thickets. April-July. General.

2. *Thaspium barbinòde* (Mx.) Nutt. Hairy-jointed Meadow-Parsnip.

Divergently branched perennials, 2 to 4 ft. tall, pubescent at nodes and sometimes on young shoots and umbels; leaves 1 to 3-ternate, segments ovate, thin, coarsely serrate, acute; umbels small, compound; flowers light yellow; fruit oval, finely pubescent. Along streams. May-June. General.

3. *Thaspium pinnatifidum* (Buckl.) Gr. Cut-leaf Meadow-Parsnip.

Similar to the preceding species, but more pubescent; leaves distant, pinnatisected into numerous linear or oblong lobes, basal leaves large and long-petioled. Woods. June-July. Hamilton Co.

11. *Ligùsticum* L.

Erect herbs with aromatic roots and large umbels of white flowers; involucre of several deciduous bracts or wanting; involucels of numerous linear bracts; calyx-teeth obsolete; stylopodium conic; fruit scarcely flattened, oblong or ovoid, ribs prominent, oil-tubes 2 to 6 in intervals.

1. *Ligusticum canadênse* (L.) Britt. Angelica.

Stout glabrous perennials, much branched, 2 to 6 ft. tall; leaves ternately once or twice compounded, segments ovate, broad, serrate, acute; those of the uppermost leaves lanceolate, entire; umbels compound, sometimes 10 in. broad. In rich woods. June-August.

12. *Coriândrum* (Tourn.) L.

Involucres wanting; involucels of few narrow bracts; calyx-teeth ovate, acute; umblets many flowered; fruit not flattened, ribs slender, oil-tubes solitary; stylopodium conic.

1. *Coriandrum satìvum* L. Coriander.

Slender glabrous annuals, 2 ft. or less tall; leaves pinnatēly decompound, lower leaflets ovate, deeply cleft and toothed, upper leaves deeply cut into linear segments; umbels compound, 1 to 2 in. broad, peduncles slender; flowers white or pinkish, petals unequal; fruit globose, not divided at commisure. Waste places. Adventitious from Eurasia. No specimens.

13. *Aethùsa* L.

Bracts of involucels setaceous, turned downward to one side; no involucre or a single bract; umbels terminal or opposite leaves; calyx-teeth obsolete, stylopodium broad; fruit dorsally compressed, ribs prominent, nearly equal, oil-tubes solitary in the intervals.

1. *Aethusa cynàpium* L. Fool's Parsley.

Leafy, dichotomously branched annual, 1 to 2½ ft. tall; leaves 2 or 3-pinnately compounded, shining, ultimate segments linear, acute, petiole bases dilated; umbels long-petioled; flowers white; fruit ovoid-globose, slightly flattened. A fetid poisonous herb, adventive from Europe. In waste places. June-October. Lake Co.

14. *Pastinàca* L.

Erect coarse herbs with a fleshy tap-root; usually no involucres or involucels; calyx-teeth obsolete, stylopodium depressed; fruit oval, glabrous, lateral ribs of the 2 carpels contiguous and forming a broad margin to the fruit.

1. *Pastinaca sativa* L. Wild Parsnip.

Biennial or rarely annual herbs, glabrous or slightly pubescent, branched, deeply grooved stem, 2 to 5 ft. tall; leaves pinnately compound, lower often 1½ ft. long, upper much smaller, segments ovate, lobed and incised, dentate, sessile; flowers yellow; fruit broadly oval, much flattened dorsally. The origin of the cultivated parsnip. Some persons are poisoned by touching the leaves. Roadsides and waste places. May-October. Common.

15. *Anèthum* (Tourn.) L.

Involucres and involucels wanting; fruit oblong, much flattened dorsally, lateral ribs winged, dorsal ones slender, sharp; oil-tubes solitary in the intervals.

1. *Anethum gravèolens* L. Dill.

Erect, glabrous, much branched annuals, 1 to 3 ft. tall; leaves finely dissected with sheathing petioled strongly nerved; umbels to 6 in. broad; flowers yellow. Leaves used for seasoning. Introduced from Europe and sometimes escaped from cultivation. July-September. Franklin Co.

16. *Heraclèum* L.

Erect, mostly pubescent herbs; bracts of involucres few or none; involucels of numerous linear bracts; calyx-teeth obsolete or small, petals clawed, obcordate, stylopodium thick; fruit much flattened dorsally, lateral ribs winged, oil-tubes conspicuous in each interval, extending to about the middle of the fruit.

1. *Heracleum lanàtum* Mx. Cow-Parsnip.

Very stout perennials, 4 to 8 ft. tall, stems often 2 in. in diameter at base, ridged, densely pubescent; leaves ternate, segments broadly ovate, irregularly toothed, stalked; umbels 6 to 12 in. broad, peduncles stout; flowers white or pinkish; fruit obovoid, finely pubescent. In moist ground. May-July. Rather general.

17. *Angèlica* L.

Tall, erect, branching herbs; involucre none or inconspicuous; involucels small or wanting; calyx-teeth obsolete or small; tip of petals inflexed; flowers white in many-flowered umblets; stylopodium depressed; fruit oval, dorsally compressed, broadly winged.

1. Umbels glabrous or nearly so, leaf-segments acute..........*A. atropurpurea*
1. Umbels densely pubescent, leaf-segments obtuse.................*A. villosa*

1. *Angelica atropurpùrea* L. Great or Purple-stemmed Angelica.

Stout glabrous perennials, umbels occasionally slightly hairy; stems dark purple, 4 to 6 ft. tall; lower leaves often 2 ft. wide, biternate, ovate, acute, thin, sharply serrate; umbels sometimes 10 in. broad; fruit broadly oval. In swamps and moist ground. May-August. Rather general.

2. *Angelica villòsa* (Walt.) B. S. P. Hairy Angelica.

Rather slender perennials, 2 to 6 ft. tall; upper stem and umbels densely tomentose-canescent; lower leaves biternate, segments thick, ovate, obtuse, finely serrate; upper ones much reduced; umbels 2 to 4 in. broad; fruit oval, pubescent. Dry rocky soil. July-September. Eastern half of state west to Adams, Fairfield and Richland Counties.

18. *Conioselìnum* Hoffm.

Erect branching herbs; involucre none or inconspicuous; involucels of narrow linear bracts; calyx-teeth obsolete; petals inflexed at tip; stylopodium depressed-conic; fruit oval, flattened dorsally, broadly winged.

1. *Conioselinum chinênsis* (L.) B. S. P. Hemlock Parsley.

Slender glabrous perennials, 2 to 5 ft. tall; lower leaves broad, long-petioled, upper ones nearly sessile, all decompound, leaflets pinnatifid; umbels 1½ to 2 in. broad, peduncles slender; flowers white; fruit oval, ribbed. In swamps and on cold cliffs. August-September. Lake and Summit Counties.

19. *Oxypolis* Raf.

Erect marsh herbs; involucre of few linear bracts or wanting; involucels of several small bracts or none; calyx-teeth acute; stylopodium thick; fruit flattened dorsally, winged, oil-tubes solitary in the intervals.

1. *Oxypolis rigídus* (L.) Raf. Cowbane.

Rather slender erect perennials, 2 to 6 ft. tall, glabrous; leaves simply pinnate, 3 to 9 leaflets, remotely toothed, linear to lanceolate; 1½ to 3 in. long; umbels compound, broad; flowers white; peduncles slender; fruit oval. Herbage is supposed to be poisonous to cattle. In swamps. August-September. From Erie, Franklin, Ross and Adams Counties westward.

20. *Zízia* Koch.

Erect perennial herbs; flowers yellow, central one of each umblet sessile; involucre none; involucels of several small bracts; calyx-teeth prominent, stylopodium wanting, styles long; fruit ovate to oblong, glabrous, somewhat flattened laterally, not winged, oil-tubes solitary in the intervals and under each rib.

1. Basal leaves ternately compound . . . . *Z. aurea*
1. Basal leaves simple, cordate . . . . *Z. cordata*

1. *Zizia aùrea* (L.) Koch. Golden Meadow-Parsnip.

Erect, glabrous, branched perennials, 1 to 3 ft. tall; basal leaves long-petioled, 2 to 3-ternate, leaflets ovate to lanceolate, sharply serrate; upper ones ternate with shorter sheathing petioles, compound umbels, 2 to 3 in. broad; no involucres; petals brilliant yellow, calyx yellowish; fruit oblong. In fields, meadows, and swamps. April-August. Rather general.

2. *Zizia cordàta* (Walt.) D. C. Heart-leaf Meadow-Parsnip.

Stout, erect, branched perennials, glabrous or slightly pubescent; basal and lower leaves simple, cordate or orbicular, crenate, long-petioled; upper ones with 3 to 5 segments, ovate, crenate or lobed; umbels of 7 to 16 umblets; fruit ovoid. May-June. Lorain, Richland, Wyandot, Madison, Franklin, Warren, Gallia, Washington Counties.

21. *Taenídia* Drude.

Involucres and involucels mostly wanting; flowers yellow, calyx-teeth obsolete; fruit flattened laterally, oil-tubes numerous; stylopodiums broad, conic.

1. *Taenidia integérrima* (L.) Drude. Yellow Pimpernel.

Slender branching perennial, glabrous, glaucus, 1 to 3 ft. tall; leaves 2 to 3-ternate, lower long-petioled, upper with short dilated petiole, segments oval, entire; umbels of 10 to 20 umblets, peduncle slender; fruit oblong, short, glabrous. Dry sandy or gravelly woods. May-June. General.

22. *Àpium* (Tourn.) L.

Involucre of 2 to 4 linear bracts; calyx-teeth obsolete, stylopodium conic, short; fruit ovate, ribs filiform, oil-tubes solitary in intervals.

1. *Apium petroselìnum* L. Garden Parsley.

Erect, much branched biennial, 1 to 3 ft. tall, glabrous; lower leaves decompound, leaflets ovate, much incised, upper leaves linear-oblong and entire; umbels spreading, 1 to 2½ in. broad, axillary and terminal; flowers greenish-yellow and inconspicuous; fruit ovoid, glabrous. Escaped from gardens. Introduced from Europe and cultivated for its leaves and roots. Summer. Madison Co.

23. *Foenículum* Mill.

Stout aromatic herbs; involucres and involucels wanting; calyx-teeth obsolete, stylopodium large, conic; ribs prominent, oil-tubes solitary in intervals.

1. *Foeniculum foenículum* (L.) Karst. Fennel.

Glabrous, branched perennial, 2 to 4 ft. tall; leaves finely dissected into numerous filiform segments; petioles broad, clasping umbels large, peduncles rather glaucous; no involucres or involucel flowers yellow; fruit oblong, nearly terete, glabrous. Leaves have medicinal value. Native of Europe, escaped from cultivation. July-September. Hocking, Scioto, Erie Counties.

24. *Bupleùrum* (Tourn.) L.

Erect herbs with simple, entire, clasping or perfoliate leaves; no involucres, involucels of 5 conspicuous bracts, about as long as the peduncles; calyx-teeth obsolete, tip of petals inflexed, stylopodium conic; fruit oval, flattened laterally, no oil-tubes.

1. *Bupleurum rotundifòlium* L. Hare's Ear or Through Wax.

Smooth, branching annuals, 1 to 2 ft. tall; leaves ovate, entire, perfoliate; terminal umbel or yellow flowers, 3 to 6 umblets; involucels very conspicuous; fruit smooth. In fields. From Europe. July-August. Warren Co.

25. *Conìum* L.

Involucres and involucels of ovate acuminate bracts; calyx-teeth obsolete, petals obcordate, tip inflexed; fruit glabrous, slightly flattened laterally; carpels wavy-ribbed, oil-tubes none, but have a layer of oil-secreting tissue.

1. *Conium maculàtum* L. Poison Hemlock.

Much branched, glabrous biennial, 2 to 5 ft. tall; stems spotted with purple; lower leaves petioled, upper nearly sessile, all decompound, leaflets pinnatifid, petioles much dilated at base; umbels 1 to 3 in. broad, peduncles slender, 1 to 1½ in. long; flowers white; fruit oblong with prominent ribs. The whole plant, especially the seed is poisonous to man and animals. In waste places. June-July. Montgomery, Knox, Lake Counties.

26. *Sìum* (Tourn.) L.

Erect herbs with stem leaves simply pinnate, lower ones often pinnatisected; involucres and involucels of many narrow bracts; calyx-teeth minute, tip of petals inflexed; ribs prominent, oil-tubes 1 to 3 in intervals.

1. *Sium cicutaefòlium* Schrank. Water-parsnip.

Stout, branched perennials, 2 to 6 ft. tall; leaflets variable, linear, in pairs, 7 to 17, acute, serrate, lowest are often finely dissected; umbels terminal and axillary, 2 to 3 in. broad; flowers white; fruit ovate, compressed, ribs prominent. Supposed to be poisonous to stock. In swamps. July-October. General.

27. *Aegopòdium* L.

Involucres and involucels wanting or rarely few deciduous bracts, umbels dense; calyx-teeth obsolete, petals inflexed, stylopodium conic; umblets many-flowered; carpels obscurely 5-angled, ribs equal, filiform, no oil-tubes.

1. *Aegopodium podogrària* L. Goutweed.

Coarse glabrous perennial, 1½ to 2½ ft. tall, from a creeping rootstock; lower leaves biternate, primary divisions stalked leaflets ovate, acute or acuminate, often oblique at base, sharply serrate, upper leaves simply ternate; umbels 1½ to 2½ in. broad; flowers white; fruit oblong, styles deflected. In waste places, adventive from Europe. June-August. Lake Co.

28. *Pimpinélla* L.

Erect herbs with stem leaves simply pinnate, lower often pinnatisected; involucre and involucels of many narrow bracts; calyx-teeth minute, tips of petals inflexed; ribs prominent, oil-tubes 1 to 3 in intervals.

1. *Pimpinella saxífraga* L. Pimpernel.

Glabrous, branched perennials, 1 to 2 ft. tall; segments of lower leaves 9 to 19, ovate, sharply serrate and incised, upper ones of fewer and narrower segments; umbels terminal and axillary, peduncles slender, 7 to 20 umblets; flowers white; fruit ovate to ovoid, compressed. Roadsides and waste places. Adventive from Europe. June-October. No specimens.

29. *Cicùta* L.

Erect herbs with compound terminal umbels of white flowers; involucre of few bracts or none, involucels of many bracts; calyx-teeth prominent, acute, stylopodium depressed; fruit slightly flattened laterally, ribs corky, oil-tubes solitary in intervals.

1. Stout, leaf-segments lanceolate to lanceolate-oblong.............*C. maculata*
1. Slender, leaf-segments linear...............................*C. bulbifera*

1. *Cicuta maculàta* L. Water Hemlock, Wild Parsnip.

Stout, branching, glabrous perennials, 3 to 6 ft. tall, from fleshy roots; stems marked with purple lines; lower leaves large, often 1 ft. long, 2 to 3 pinnate, long petioles, upper leaves smaller, leaflets ovate to lanceolate, sharply and coarsely serrate umbels many-flowered, pedicels unequal; flowers white; fruit shallowly grooved at commisure. Whole plant violently poisonous to man and animals. Has destroyed many human lives. June-August. In moist soil. General.

2. *Cicuta bulbífera* L. Bulb-bearing Water-Hemlock.

Slender much-branched perennials, 1 to 3½ ft. tall; lower leaves 2 to 3-pinnate, segments linear, sparingly serrate, upper ones less divided and bearing clusters of bulblets in axils. Supposed to be very poisonous. In swamps. July-September. Northern part of the State to Perry and Clark Counties.

30. *Eùlophus* Nutt.

Involucres of one bract or none; involucels of narrow acuminate bracts; calyx-teeth prominent, petals obovate, tip inflexed, stylopodium conic; fruit glabrous, styles persistent, recurved, ribs filiform, 1 to 5 oil-tubes in intervals; umblets many-flowered.

1. *Eulophus americànus* Nutt. Eastern Eulophus.

Slender glabrous perennials, 3 to 5 ft. tall, from deep tuberous roots; basal and lower leaves large, long-petioled, 2 to 3-divided into linear segments, upper leaves similar but smaller and with shorter petioles; umbels terminal, 2 to 4 in. broad, peduncles slender; flowers white or pinkish; fruit oblong. In dry soil. July. No specimens.

31. *Càrum* L.

Involucres and involucels of few to many bracts, inconspicuous, and may be early deciduous; calyx-teeth minute, petals inflexed, stylopodium conic; fruit slightly compressed laterally, ribs filiform, oil-tubes solitary in intervals.

1. *Carum càrui* L. Caraway.

Branching, glabrous biennials or perennials, 1 to 2 ft. tall; all leaves pinnatisected into filiform or linear divisions, bases of petioles much dilated; umbels 1 to 2½ in. broad; flowers white, occasionally pink or yellowish; fruit oblong, ribs conspicuous. Seeds have medicinal value and are used in flavoring. Native of Europe. Escaped from cultivation. May-September. Columbiana, Lorain, Ashland, Fulton Counties.

32. *Cèleri* Adans.

Involucre and involucels small or none; calyx-teeth obsolete, petals obovate, inflexed at the tip, stylopodium depressed; carpels 5-angled, ribs prominent; umbels terminal and opposite the leaves.

1. *Celeri gravèolens* (L.) Britt. Celery.

Erect glabrous perennials, 1 to 3 ft. tall; leaves pinnate, lower ones long stalked, upper nearly sessile, leaflets thin, broadly ovate, coarsely toothed and incised; umbels of 2 to 7 umblets, opposite the leaves and terminal; flowers very small, white; fruit ovoid, small. Petioles are eaten and seeds used in seasoning. Native of Europe. Escaped from cultivation. May-July. Highland County.

33. *Erigenìa* Nutt.

Glabrous herbs from a deep tuber; calyx-teeth obsolete, petals flat, obovate or spatulate; fruit nearly orbicular, notched at both ends, ribs slender, oil-tubes in intervals.

1. *Erigenia bulbòsa* (Mx.) Nutt. Harbinger of Spring. Pepper and Salt.

Nearly acaulescent perennials, scapose stem, 3 to 9 in. tall; leaves few, petioled, 2 to 3-ternate, segments oblong, obtuse; upper one involucrate, smaller, short-petioled, petioles much dilated at base; umbels terminal, compound, few umblets; flowers white, anthers dark purple; fruit broader than long. Deciduous woods. February-June. General.

A REVIEW OF THE GENUS ERISTALIS LATREILLE IN NORTH AMERICA.

PART II.*

FRANK M. HULL,
Ohio State University.

The studies below represent a continuation of those which were published in the OHIO JOURNAL OF SCIENCE a short time ago. In all, seven species have been described as new. These represent species which the writer has been unable to place in existing descriptions. These older descriptions, however, of unrecognized species, are in no slight degree vague and indefinite, and in few cases is one able to feel sure of their characterization. Hence, it is not entirely impossible that when the types of these old species are examined (according to the evidence of several authors, some of these are no longer in existence), one or two of the present described species may be found identical. Many of the old descriptions, are, as has been noted by others, a characterization more applicable to a genus or a group, rather than to any definite species.

Mention was made in Part I of these studies, of a discussion of the remaining unrecognized species from North America. It has not been found practical to include this here and the treatment of these remaining forms has been reserved for a future paper.

THE SCUTELLARIS GROUP.

(Group description.)

The forms placed here make a rather unique group, distinguished chiefly by their elongated abdomen and thickened hind femora. Unlike the species of the following group, while sometimes brilliantly marked with yellow, they are usually, for the larger part black or brown.

Of moderate size to large; very scantily and short pilose. Head more or less hemispherical, slightly variable in shape. Eyes pilose on the upper half. Frontal triangle just above the antennæ, obtusely projecting in the male; slightly projecting in the female. Antennæ of the usual size; arista bare.

* Part I, see this Journal: Vol. XXV, p. 11, Jan., 1925.

Thorax opaque, transversely fasciate, and often marked by shining cross bands. Abdomen long and slender, widest on the second segment, thence tapering posteriorly. Hind femora considerably thickened; hind tibiæ flattened and arcuate, with a sharp apical spur.

The above assemblage of characters will be seen to embrace those used by Williston to designate his species of *Doliosyrphus*, a genus hardly tenable, based as it is, chiefly on the protruding frontal prominence of the male. This is to be found to but a slight extent, in the females. The elongate condition of the abdomen is found to have intermediate forms in such species as *æmulus*, *agrorum*, and *spectabilis*. While these forms are readily placed within the group, they are but little more elongate than the usual *Eristalis*.

KEY TO THE SPECIES OF THE *Scutellaris* GROUP.

1. Hind femora yellowish to reddish........................*precipuus* Will.
   Hind femora black or brown..2
2. Velvet black bands of thorax broken up into spots..........*cyatheus* sp. n.
   Velvet black bands continuous..3
3. Scutellum in a large part black............................*volaticus* Will.
   Scutellum not in large part black....................................4
4. Scutellum brown in color...5
   Scutellum wholly yellow..6
5. Light spots on the third and fourth segments of the abdomen...*æmulus* Will.
   Fourth segment, and usually whole of third segment, black..*spectabilis* n. sp.
6. Third joint of antennæ light yellowish red...................*agrorum* Fabr.
   Third joint of antennæ black or nearly so............................7
7. Median opaque stripe of second segment of abdomen does not reach the posterior band; hind tibiæ reddish to brown (female).........*conicus* Fabr.
   Median opaque stripe of second abdominal segment reaches the posterior band; hind tibiæ black or nearly so...8
8. Margins of scutellum fringed with dense stubby black pile. (Male, female). *conicus* Fabr.
   Scutellum not thus fringed; only scattering brownish hairs..*scutellaris* Fabr.

Eristalis precipuus Will.

(Plate I, Fig. 8.)

Male; female. Antennæ dark reddish brown. Bare area of cheeks, narrow; together with facial stripe, shining dark brown. Pile of face dense, appressed, silvery, totally obscuring the ground color. Pile of lower half of front, just above antennæ, black. Thorax opaque gray, marked as follows: an opaque velvet black band extending between the humeri, widely interrupted medianly; a second black band, practically continuous, immediately behind the suture. Immediately in front of this (presutural), is a very narrow, widely interrupted, silvery line or band; immediately behind the suture, a wide steely blue band. Pleuræ largely silvery gray pollinose. A small spot above the base of the wings likewise silvery gray pollinose. Scutellum yellow, narrowly black basally. Abdomen opaque black; second segment with a pair of large, quadrate yellow spots, reaching the margin in their full length. Third

segment with similar yellow spots, narrowly connected on the anterior margin. Fourth segment with a complete steel blue, shining cross band; median black of second and third segments extended along the posterior margin to the sides. Segments two, three and four with a narrow yellow posterior margin. Yellow spots of female often obsolescent, becoming metallic steel blue. Legs light yellowish brown; pile long, whitish. Last two joints of all the tarsi blackish, pile black. Wings nearly hyaline, slightly grayish. Length 15 mm.

Description drawn from one female; Sao Paulo, Brazil, (collection Mr. C. H. Curran), and the description by Williston, Trans. Amer. Ent. Soc., Vol. XV, p. 280. The typical specimens were from Chapada, Brazil.

Eristalis cyatheus n. sp.

(Plate I, Fig. 9; Plate II, Fig. 13.)

Female. Facial stripe and cheeks, shining, jet black. Face very scantily clothed with light, white pollen; black ground color plainly apparent. Facial stripe limited to the tubercle, the latter more prominent than in *scutellaris*. Pile of lower half of front, or just above antennæ, black. A few hairs below antennæ black, becoming white and more numerous along the sides, lower down. An opaque black band extending across the middle of front, to the margins of the eyes, and a band before and behind, silvery pollinose. Antennal prominence shining black, an opaque triangular black spot just above the apex directed towards the vertex. Antennæ lacking. Thorax dark gray, feebly shining, marked as follows: A large, opaque, velvet black spot in the anterior lateral corners of the dorsum, a wide anterior median black band (may be narrowly divided medianly) produced posteriorly, not reaching the suture, and a large, subtriangular, opaque black spot, just behind the suture, on either side. Pleuræ black, sparsely white pilose. Scutellum deep, opaque, velvet red. Abdomen shining black, with a slight steely blue cast, marked with opaque black as follows: A small, median, quadrate spot on the anterior margin of the second segment, together with a median interrupted band on the posterior margins of the third and fourth segments. Very narrow, yellow posterior margins, on segments two, three and four. All the femora shining black. All the tibiæ and tarsi yellowish red. Wings grayish hyaline, with a large blackish spot on the outer half, sharply defined basally. Length 15 mm.

One female, San Sebastian, Brazil. Type in the collection of Mr. C. H. Curran.

Eristalis volaticus Williston.

Male. Facial stripe, cheeks, and front, shining black. Face deeply obscured by dense, pale yellowish to whitish pollen. First and second joints of antennæ dark blackish brown, third light reddish; arista yellow. Thorax gray, feebly shining, marked vaguely by a large, opaque

black spot in each lateral anterior corner, almost continuous medianly, and a similar, broken band, just back of the suture; a median black stripe produced posteriorly, not reaching the suture. Pleuræ, black, largely dark brownish pilose. Scutellum yellow, wholly obscured, except for a small round spot apically, by dense, woolly or curly, velvet black or reddish brown pile. Second and third segments of abdomen wholly yellow, except as follows: a narrow, median black stripe, of uniform width, on both segments, interrupted on the posterior margin of the second, by the yellow posterior margins; in the second segment, slightly dilated posteriorly, in the third the dilation becomes a band, reaching the side margins of the segment. Fourth segment wholly black save for the narrow yellow posterior margin. All the femora wholly shining black. Basal half of tibiæ light yellowish brown, remainder of tibiæ and tarsi black; clothed with short, dense, whitish or yellowish hair. Wings clouded with brown, especially along the anterior margin. Length 9–11 mm.

One specimen, San Sebastian, Brazil, and a part of the Williston material, Chapada, Corumba, and Rio de Janeiro, studied.

Eristalis æmulus Will.

(Plate I, Fig. 1; Plate II, Fig. 18.)

Male, female. Antennæ dark brown, arista of the same color. Facial stripe and cheeks, shining reddish brown. Face obscured by dense, appressed, pale yellowish white pile and pollen, extending a part of the way up the front, along the eyes. Front dark brown, vertex black; pile dark. Thorax marked by four bands before the scutellum, the first three of nearly equal width, and continuous; between the humeri, an opaque gray band, immediately behind is an opaque black band, followed by a band with a strongly steel blue cast; immediately before the suture is found the usual, narrow, interrupted, white pollinose band or line. Just past the suture is a wide, black, continuous band; remainder of the thoracic dorsum, strongly steel blue. Scutellum light brown, feebly shining on the rim. Second segment of the abdomen light brown, subtranslucent, marked with black, or very dark brown, as follows: A median stripe of nearly equal width, continuous posteriorly with a narrow band on the posterior margin. Third segment of a similar color, with a wide posterior marginal band, and a round, median spot, black. Fourth segment sometimes with a small light spot on either side, widely separated by black; a shining cross band on the middle of the segment; other parts of abdomen opaque or very feebly shining. Sides of all the segments, very narrowly blackish; narrow, yellow, posterior cross bands present. Abdomen of a peculiar shape, very wide on the second segment, tapering slightly and very suddenly tapering on the third segment; fourth segment less than a third the width of the second, tapering slightly. Abdomen not very greatly longer than broad. Legs more or less evenly dark brown, shining; tibiæ and tarsi lighter in color. Wings with the usual brown clouds apically. Length 14 mm.

Recorded by Williston, from Mex., Guatemala, and Panama. Nine specimens, from Bartica, British Guiana, June, July. Collections of Ohio State University and Mr. C. H. Curran.

The difference in the contiguity of the eyes of the male, between this species and *agrorum*, is very slgiht indeed. Williston further describes the hind femora of *æmula* as slenderer than *agrorum;* actually it is the reverse, though the difference is slight. There is moreover, in *æmulus*, a slight, elongate protrusion, on the lower surface of the hind femora, apically, lacking in the other species; the hind tibiæ are more arcuated.

Eristalis spectabilis n. sp.

(Plate I, Fig. 2.)

Female. Antennæ dark reddish brown; arista of the same color. Facial stripe and cheeks shining black. Ground color of face densely obscured by appressed, silvery pile. Front blackish, pile black. Thorax gray, moderately shining, marked by an opaque, velvet black band, continuous between the humeri, and a similar, wider band just behind the suture. Just before the suture, is a widely interrupted, very narrow, silvery pollinose band. Scutellum brown, slightly shining. Abdomen black, largely shining; marked as follows: Two, large, subquadrate, or roughly oval, dark shining, slightly reddish brown spots on the second segment, separated medianly by chiefly opaque black stripe, the latter continuous with a black posterior margin. Small spots of the same color as those on the second, in one specimen, on the anterior margin of the third segment, widely separated by black. Black of third and fourth segments shining, a small median spot anteriorly on the third, opaque. Side margins of all the segments black. Usual narrow yellow posterior bands present. Legs shining black; tibiæ dark brow, lighter basally. Wings heavily clouded with brown, especially on the apical half. Length 15 mm.

Type female and two paratype females, Caura Val., Venzuela, collection of C. H. Curran. The species resembles somewhat, a very blackish, smoky, *vinetorum*, but is very different in a number of respects, besides being elongate. It is, however, not very greatly elongate, and resembles *æmulus* in this respect, the drawn out fourth and fifth segments contributing to this appearance. Much darker and blacker than the preceding species. The male probably resembles *æmulus* in shape.

Eristalis agrorum Fabr.

(Plate I, Fig. 3.)

Male, female. Antennæ and facial stripe light brownish red; cheeks very dark, shining, brownish red. Front, shining, dark reddish brown,

above antennæ, becoming more opaque and brownish black towards the vertex. Face obscured by dense, appressed, pale yellowish white pile and pollen. Thorax nearly opaque, slightly brownish or yellowish gray, marked by black as follows: A narrow continuous band between the humeri; a similar band, about three times the width of the first, immediately behind the suture, slightly crescentric; narrow, white, pollinose, interrupted band before the suture, scarcely present. Scutellum yellow, opaque, sometimes tinged with red. Second abdominal segment yellow, marked by a rather slender, median, black stripe, wider in the female, usually more slender posteriorly, and continuous with a quite narrow, sometimes obsolescent, posterior marginal band. Third segment likewise yellow, with a black, posterior marginal band; in the male, with median, contiguous, round black spot on the anterior margin, and in the female, a similar, quadrate spot. Fourth segment wholly black, with a transverse, medianly interrupted, metallic cross band. Segments two, three and four, with narrow yellow hind margins. Femora shining black; hind tibiæ dark brown, front tibiæ, and middle tibiæ more extensively, pale yellowish basally. Tarsi black. Wings nearly hyaline, sometimes slightly infuscated. Length 15 mm.

Material studied consists of that recorded by Williston from Chapada, Brazil. The abdomen is not especially elongate, and is more flattened than is common among the genus. Similar to *vinetorum* especially in the markings of the thorax, but presenting numerous differences. In that species the scutellum is uniformly brown, as are the markings of the abdomen. In *agrorum*, while often tinged with red, the markings are distinctly yellow, at the most, tinged with brown. It is a rather light colored species.

Eristalis conicus Fabr.

(Plate I, Fig. 6.)

Male, female. Antennæ dark brownish black; third joint one and a half times as long as broad, arista reddish brown. Facial stripe, front and cheeks, shining black. Cheeks densely white pollinose, in the female extending narrowly up along the eyes, to nearly half the length of the front. Thoracic pattern similar to that of *scutellaris*. Scutellum yellow, heavily fringed on the margin with dense, stubby, black pile, wholly opaque. Median black band of second segment of the abdomen, not continuous in the female, with the posterior marginal black band of that segment, thus differing from the female of *scutellaris*. Abdominal markings otherwise as in *scutellaris*. All the femora shining black; hind tibiæ dark reddish brown; hind tarsi, front and middle tibiæ and tarsi, rather light brownish red. Wings heavily clouded, particularly on the apical half. Length 10–12 mm.

About thirty specimens studied. Recorded from Bartica, Kartabo, British Guiana; Rio de Janeiro, Chapada, Brazil;

and Livingston, Guatemala. Collection of C. H. Curran, Ohio State University and the author. A species remarkably close to *scutellaris*, but distinguished in the female, by the discontinuous, opaque black band of second segment, lighter colored tibiæ and tarsi, and in the male, by the scutellum being always beset with dense black bristles, longer antennæ, etc. They seem to differ fairly constantly in size.

Eristalis scutellaris Fabr.

(Plate II, Figs. 16, 19.)

Male, female. Antennæ very dark brownish black, third joint slightly longer than broad; arista black. Front, facial stripe and cheeks, shining black. Face heavily obscured by dense silvery pollen. Pile of face and occiput, sparse, silvery; of front and vertex, black; of eyes, light, slightly reddish brown. In the female, the silvery facial pile extends narrowly up along the orbits, half the distance of the front. Thorax gray, feebly shining, marked as follows: a narrow, black, opaque band, continuous between the humeri, in one specimen extending widely, anteriorly, between the humeri; a second wider, similar band, immediately behind the suture, followed by a wide, shining steel band. Before the suture is found a narrow, widely interrupted, silvery pollinose band, in one specimen rather yellowish. Pleuræ largely brownish gray, pale pollinose. Scutellum deep yellow, very narrowly black basally, wholly opaque. Abdomen opaque black, marked as follows: A pair of large, sharply quadrate, yellow spots on the second segment, separated medianly, from each other, and posteriorly from the margin, by a black band. Margins frequently narrowly black. Third segment similar. Fourth segment wholly black, a continuous, transverse, steely blue band in the middle. Segments two, three and four, with narrow yellow margins. Yellow spots of female usually obsolete; replaced by shining, steely blue. Legs shining black; anterior and middle tibiæ largely dark shining red. Wings heavily clouded with black, particularly on the apical half. Length 14–16 mm.

Thirty-five specimens studied. A large and brilliantly marked species, with an extensive synonomy. Recorded from Chapada, Rio de Janeiro, Brazil; Kartabo, Bartica, British Guiana; Mexico, New Mexico and Panama. Material studied is from the collections of C. H. Curran, Ohio State University, R. C. Shannon and the author.

The Aeneus Group.

(Plate II, Figs. 17, 20.)

Species distinguished primarily by the spotted eyes, and by the bare eyes on the upper half. The thorax is usually longitudinally striped and the species are often metallic in coloration. A group containing a large number of Oriental and African species, often separated under the genus *Lathyrophthalmus*. The species are, as Bezzi has remarked, quite variable in some of their characters. Still the group is a useful one. Many of the species are of brilliant coloration and this is particularly true of the sole representative in North America. The latter, *Eristalis æneus* Scop., is a common, widespread and well known species. It is slightly smaller than the average *Eristalis*, almost wholly metallic greenish or brassy, usually with five opaque longitudinal vittæ on the dorsum of the thorax. According to Herve Bazin, the form with striped thorax is the variety *taphicus* Wd. This form is represented in Figure 17. The arista is bare, microscopically pubescent.

The Dimidiatus Group.

(Group description.)

Eyes pilose on the upper anterior portion. Antennæ typically dark brown, red or black; arista plumose to bare and microscopically pubescent. Cheeks shining black; ground color of face dark, pile light in color. Facial stripe and prominent "knob" or tubercle, shining black to dark brown or red. Pile of vertex and the lower part of occiput rather long abundant.

Thorax some shade of dark brown or black; usually highly shining and unicolorous; sometimes very obscure darker areas may be seen at an angle. Scutellum likewise shining, as a rule nearly concolorous with the thorax. Pleuræ black or brown. Pile of thorax and scutellum abundant but rather short, generally light in color.

Abdomen in most species highly shining, less so on the second segment; following segments rarely wholly shining, usually with posterior or anterior opaque marginal bands, often interrupted or broken up into spots. Light colored spots of fore part of abdomen always more distinct in the male, very often obsolete in the female, occasionally in the male. Segments two, three and four with the characteristic narrow yellow marginal bands posteriorly. Pile thick but quite short; variable in color. Legs usually characteristically marked; mostly shining black, with the basal half of all the tibiæ sharply yellow, sometimes whitish. Hind femora slender. Wings seldom wholly hyaline, usually with an infuscation on the anterior half, heaviest about the stigma, sometimes with a well defined black or brownish spot; decidedly variable.

One of the most troublesome groups in the genus. The recognition in this country of *nemorum* and *rupium*, both European species, by Dr. R. C. Osburn (Jour. New York Ent. Soc. XXIII,

139) and the variability of certain forms, together with some little sexual dimorphism in certain species, all adds to their complexity and the difficulty of separating them out. Distinctions between species, based on wing markings, are highly variable and untrustworthy; only *dimidiatus* has really hyaline wings and it not perfectly. The black opaque markings of the third abdominal segment, so often made use of, are distinct in only three species and in the remainder variable. The characters here used are a combination of the opaque markings of the abdomen, color of the legs, pile, antennæ and general coloration. Great care has been taken to use those characters most easily discernible and least variable; with all the caution that has been used there must still remain many imperfections. The group is considered characterized by their general strong shining appearance and comparatively short pile, usual dark coloration, etc., in contrast to more opaque species such as *arbustorum*, *brousi*, etc. This latter group finds several members in Europe. As it cannot be denied that certain specimens of *arbustorum* and *brousi* become somewhat "shining on the thorax," though decidedly opaque upon the abdomen, these two species have also been included in the key. The plumosity of the arista in the dimidiatus group varies considerably. We find on one hand, tolerably plumose species such as *rupium*, with ten to twelve plumulæ, *saxorum* with six or eight, *dimidiatus* with only two or three, and on the other hand *latifrons* with none. In *obscurus* there are a number of short hairs; it can hardly be called plumose.

Among the older species of this country, *obscurus* seems not to have been well understood; large series of what I have considered this species, as well as several other species, have been taken by Professor J. S. Hine in Alaska, and have enabled the writer, perhaps, to characterize them better. *Eristalis inornatus* has not been certainly recognized. Originally described from a single poorly preserved specimen. Although it has been reported as taken several times since, the writer feels sure that most if not all of these have been confused with other members of the group; one specimen that has come to hand, identified as *inornatus*, turns out to be *rupium*.

KEY TO THE SPECIES OF THE *Dimidiatus* GROUP.

1. Basal third of hind tibiæ light yellowish 2
   Basal third of hind tibiæ not of this color (*obsoleta* group) ..... *tenax* Linne.
2. Basal two-thirds of wing margin brown in color .... *compactus* Walk.
   Basal two-thirds not of this color; nearly or completely hyaline or with infuscated spot near stigma 3

3. Posterior margin of third segment with a fringe of pale golden pile; opaque markings limited to two widely separated oval spots, or entirely lacking. *latifrons* Lw.
Not with a fringe of pale golden pile on third segment; opaque markings usually in the form of bands, sometimes spots, rarely absent..............4
4. Thorax deep bluish black; opaque bands of third abdominal segment complete; wings always with a spot in neighborhood of stigma...*saxorum* Wied.
Thorax not of that color...5
5. Third abdominal segment with a widely interrupted opaque cross band; third and fourth segments each with a small median, anterior opaque spot; wings hyaline...*dimidiatus* Wd.
Third and fourth segments of abdomen not as above; wings hyaline or infuscated...6
6. Males...7
Females...13
7. Basal joints of hind tarsi pale in color..........................*rupium* Fabr.
Basal joints of hind tarsi dark..8
8. Third and fourth abdominal segments with a median, opaque, elongate spot..9
Third and fourth abdominal segments not with such a spot................10
9. Spots of second abdominal segment highly shining at least in part, yellow; pile of thorax light yellow; shining facial stripe prominent............. *temporalis* Thomp.
Spots of second abdominal segment opaque or very feebly shining; pile light brownish to reddish; facial stripe usually quite narrow or lacking.......10
10. Yellow of second and third segments confluent for nearly its width; dorsum of thorax usually with faint darker spots; shining facial stripe very narrow to obsolete...11
Black of second segment posteriorly reaching nearly to the lateral margins; thorax entirely unicolorous; shining facial stripe prominent..............12
11. Basal joint of middle tarsi yellowish except at tip; a transverse basal band of opaque black on fourth segment.........................*arbustorum* Linne
Basal joint of middle tarsi entirely brown; fourth segment with a minute basal spot of opaque black or entirely shining....................*brousi* Will.
12. Pile of face and thorax yellowish to reddish; usually with light spots on third abdominal segment; ground color of face light...............*nemorum* Linne
Pile of face and fourth abdominal segment white; light spots only on second segment; ground color of face black........................*obscurus* Lw.
13. Second abdominal segment very feebly shining; dorsum of thorax with faintly indicated darker spots; shining facial stripe very narrow or lacking (*arbustorum* group)...14
Second abdominal segment at least in part highly shining; thorax entirely unicolorous; facial stripes quite prominent............................15
14. Basal joint of middle tarsi yellowish except at tip; a transverse basal band of opaque black on fourth segment.....................*arbustorum* Linne.
Basal joint of middle tarsi entirely brown; fourth segment with a minute basal spot of opaque black or entirely shining.....................*brousi* Will.
15. Light markings of second abdominal segment usually large or quite distinct; third and fourth segments with a median opaque elongated spot; pile yellowish, never brownish on dorsum of thorax............*temporalis* Thomp.
Light markings usually nearly obsolete or much suppressed................16
16. Thorax more brown; pile brownish to reddish..............*nemorum* Linne.
Blackish species, particularly on the thorax; pile pale yellow to whitish...17
17. Basal joints of hind tarsi pale; third joint of antennæ red to dark reddish brown; infuscated spot of wing quite distinct at least from the basal half of the wing. *rupium* Fabr.
Basal joint of hind tarsi dark in color; third joint on antennæ black, never dark brown or red; infuscation of wing much lighter and diffused over the whole basal anterior portion of wings to stigma (see discussion under *temporalis*. *obscurus* Lw.

Eristalis dimidiatus Wied.

Male, female. Antennæ black. Facial stripe and cheeks shining black; ground color of face black; pile of face, vertex and front pale yellowish white, on upper part of vertex black. Thorax wholly shining greenish black, with three very faint opaque vittæ; scutellum nearly concolorous. Pile of thorax wholly pale yellowish. Second segment of abdomen black, a light brownish spot on either side, occasionally obsolescent, is separated by black in the middle of the segment. Remaining segments wholly black. Third and fourth segments wholly shining save for a median anterior opaque spot on each and an oval spot on each side of the third segment, posteriorly. Posterior marginal bands of segments whitish. Legs shining black, the basal half of all the tibiæ pale yellowish white, usually sharply marked. Wings hyaline, rarely with a slight infuscation on the middle of the anterior half. Length: 10–13 mm.

Perhaps the commonest, or at least the best known species in the group. The characters that at once mark the species are its black color, greenish or brownish black thorax, characteristic opaque spots of third and fourth segments and the whitish areas on the tibiæ.

Eristalis latifrons Lw.

Male, female. Antennæ black, arista bare to microscopically pubescent; facial stripes and cheeks shining black. Pile of face, front and vertex, pale yellowish white, longer than in most species of the group. Thorax greenish brown, shining, with no traces of opaque markings. Scutellum yellowish brown. Pile of thorax rather thick, yellow. Abdomen greenish black; first segments with yellowish brown spots on each side, widely separated medianly, frequently obsolescent or totally absent. Abdomen wholly shining; an interrupted opaque posterior band on the second segment, occasionally an oval, opaque spot on each side of the third segment in the male. Posterior margins of second, third and fourth segments whitish, with a characteristic fringe of rather long, pale pile. Apices of femora and abasal half of tibiæ yellowish; legs otherwise shining black. Wings sometimes hyaline; usually with a brownish spot in the middle of the anterior half. Length 9–14 mm.

A widespread species, more abundant in the southern half of the United States. The almost wholly shining abdomen, marginal fringe of whitish pile, greenish color, etc., all serve to make the species a characteristic one.

Eristalis saxorum Wied.

Male, female. Antennæ black, sometimes dark reddish brown; arista slightly plumose basally. Facial stripe, cheeks and ground color of the face, black. Pile of face white, of upper half of front and vertex,

black. Thorax black, with strong metallic bluish reflections. Scutellum of a similar color and reflection; but often dark reddish brown. Pile of thorax short, longer on the pleuræ, pale in color. Abdomen black; a light brownish spot on either side of the second segment, quite frequently obsolescent, and widely separated medianly; narrow yellow posterior marginal bands usually prominent; often with a quite strong bluish tinge, and the segments highly shining, even sometimes metallic. Second segment largely opaque save on the spots; third and fourth segments with characteristic opaque, marginal bands, on both anterior and posterior portions, the anterior band sometimes obsolescent. Legs typical for the group; light area of the tibiæ, whitish. Wings always with a fairly well defined brown stripe or spot, on the middle and anterior half, variable in extent. Length 10–13 mm.

A common, well known species, seemingly limited to the northern half of the eastern United States. Professor J. S. Hine tells me he has never met with the species in Ohio. It is recorded from the District of Columbia. My material is from Massachusetts and New York. Distinguished by its strongly steel blue coloration, and largely shining to metallic abdomen.

Eristalis compactus Walk.

Male, female. Antennæ, bright brownish orange, in two specimens reddish brown; quite large, two-thirds to twice larger than usual. Facial stripe wide, it and cheeks shining black; ground color of face black. Pile of face light, rather short and sparse, in considerable contrast to such forms as *latifrons*, *nemorum*, etc.; pile yellowish on front and vertex and black about the ocelli, sometimes black on the front likewise. Face more produced below than in other species. Eyes wholly pilose. Thorax dark shining brown, scutellum strongly reddish; pile of former light yellowish brown on top, reddish on the sides; on the latter black upon the disc, yellowish on the margin. Abdomen black, the spots of the second segment strongly reddish; the narrow yellow posterior marginal bands very prominent, largely shining; opaque bands on the second, third and fourth segments, often obsolescent. Pile on spots of second segment bright golden red. Legs yellowish red, basal half of hind femora, greater part of front and middle femora and last two joints of the tarsi, black. Wings with a characteristic brownish band on anterior basal portion of wing. Length 9–10 mm.

A short, stout, compact little *Eristalis*, well deserving its name. The band of the wing and the shining reddish coloration separate it at once from its congeners. Specimens studied are from New York and New Hampshire. Specimens received from Mr. Raymond C. Shannon were taken on flowers of *Caltha palustris*.

Eristalis temporalis Thompson.

Male, female. Antennæ very dark brownish black; arista slightly plumose basally; facial stripe prominent, together with cheeks shining black; ground color of face black. Pile of face light brownish yellow in color, sparse; on front and vertex similarly colored. Face and front of female unusually broad. Thorax dark shining, greenish or brownish black. Scutellum not quite so dark, brownish, shining. Abdomen greenish or brownish black; second segment with a shining, large, prominent, sharply marked, brownish yellow spot on either side, rather widely separated by opaque black medianly. The posterior marginal bands of the segment unusually prominent, light yellow. Segments three and four shining, save for an opaque, posterior, rarely interrupted band on the third segment and a median anterior "dagger-like" spot on both third and fourth segments. Legs black, moderately shining, bases of hind femora, apices of all the femora, basal half of hind and front tibiæ, greater part of middle tibiæ basally, pale yellowish. Wings hyaline, or very faintly, scarcely perceptibly, infuscated in the middle and anterior half. Length: 10–15 mm.

The above description may be considered typical; description of one or two variations are given below.

With this and the following three species, "our trouble begins." The discovery of certain European species within the confines of North America has not seemed to clarify a situation, already perplexing enough, due to older species being poorly understood and studied from but few specimens. The writer has studied good series of most of the forms and believes he has come to a fairly good understanding of their characters; the obscurity of these, however, renders their description a most difficult matter.

A study of a series of specimens betrays several interesting facts. The females are found to be more difficultly distinguishable and are further found to be more "shining" than the males.

Eristalis temporalis differs from all the others in at least one respect; in both males and females of the typical variety, the light colored spots of the abdomen are about equally prominent.

The males of the typical variety can only be confused with *obscurus* and a variety of *nemorum*. This variety of *nemorum*, as will be further discussed under that species, is a form which lacks the second pair of light spots on the abdomen. Typically this species seems to have light brownish spots on both the second and third segments. From the variation, *temporalis* may be distinguished by the pale yellow color of its pile, the wholly shining thorax, with never a trace of darker spots or bands, and

the *yellow* abdominal spots. The spots of *nemorum* are reddish, the pile and the whole insect has a reddish or fulvous appearance; the thorax is considerably more opaque, with traces of dark spots or vittæ, etc. Occasionally one finds *nemorum* with only deep yellow pile. In *nemorum* there are traces of a median dagger like spot on the third and fourth segments, never so prominent as is usually found in *temporalis*. The males of *rupium* likewise exist in a similar variety to that of *nemorum;* they may be at once separated from *temporalis* by the well defined infuscation of the wings, reddish color, etc.

The females of the typical form, can not be confused with the others; in all the remaining species the females have the light spots of the abdomen obsolescent.

A certain form of female in this group is quite commonly collected, often among *temporalis*, and is usually considered to be a variety of that species. It is, however, very much closer to the females of *obscurus*, and as I shall show below, almost indistinguishable from them. Still the one character which links it with *temporalis*, I believe to be more important than the several by which it resembles the female of *obscurus*. It is a peculiar situation. Specimens of the form are nearly always found among collections of *temporalis*. The true *obscurus*, about the validity of which there can be no doubt, is too poorly known at present, for us to say what species or forms consort with it. The chief difference of the variation lies in the fact that the light spots of the abdomen are entirely obsolescent.

What I consider the females of *obscurus*, have been taken from a large series of that species, associated in the fields with the males, and collected by Professor J. S. Hine in Alaska. These males of *obscurus* seem quite distinct. The variety above mentioned, which I shall call *beta*, n. var. (vide inf.), for it is certainly a variety whatever the species, further departs from temporalis and resembles *obscurus*, in having the pronounced, shining greenish black color of the latter, together with very narrow yellow, posterior bands on the segments. The marginal bands in the former species are much wider. This species has always been considered the exclusive possessor of dagger-like median spots on the third and fourth segments, but traces of such may be found in all degrees, in *obscurus*, and, as already remarked, in *nemorum*. They are frequently absent in these two species; I have never seen them lacking in *temporalis*. The

variety *beta* agrees with *obscurus* in having these spots usually slight. In *temporalis* the wings are substantially hyaline; in all my specimens of *beta* and *obscurus* there is a distinct infuscation in the stigmal area of the wings. In one respect the specimens of the variety differ from *obscurus* and agree with *temporalis;* the latter species has the middle tibiæ yellowish for their basal two-thirds or more, while in the other, never more than the basal half is yellow.

The males of the species differ from the males of *obscurus* in the following respects: in the latter species the abdomen is considerably less shining, the light spots of the second segment in particular, nearly opaque (shining in *temporalis*), and of a pale yellowish white color. The pile of the fourth segment wholly white; usually yellowish in the other species.

Two males that differ in having the femora as well as the tibiæ and tarsi, largely yellowish, I call variety *alpha*. n. var. (vid. inf.). In some intangible way the yellow of the abdominal spots is deeper and more conspicuous. It closely approaches certain European forms, from which it is, however, quite different.

Some sixty or seventy specimens of *temporalis* have been studied from British Columbia, Oregon, California and Wisconsin.

Variety *beta* n. var. All females; type: Banf, Alberta, June 11; paratypes: Stanford U., Calif., June 16, 1910; Walnut Creek, Calif.; Mary's Peak, Oregon (In the author's collection).

Variety *alpha* n. var.; type, a male, Banf, Alberta (J. F.). In the author's collection.

Eristalis rupium Fabr.

Female. Antennæ usually dark brown or red, never black, sometimes rather light reddish; first two joints always shining black; arista plumose on the basal half. Cheeks shining black. Face shining; it and ground color of face vary from a rather light reddish color to black; face somewhat pollinose, pile sparse, yellowish white in color. Pile of front and vertex yellowish to white; blackish about the ocelli. Thorax dark shining brownish black, no darker markings on the disc; scutellum concolorous, pile yellowish. Abdomen shining black; second segment opaque black, the spots always obsolete, metallic, black and shining. Third and fourth segments with opaque bands posteriorly and narrower bands, sometimes lacking, anteriorly; bands of both segments often interrupted. Hind femora, except basally and apically, front and middle tibiæ femora, save on their apices apical half of hind tibiæ, apices of remaining tibiæ and last two joints of all the tarsi, black; otherwise

yellow or reddish. Wings with a dark brown infuscation in the middle and on the anterior half, sharply delimited from the basal half of the wing, although it may be surrounded by lighter infuscation on either side.

Male. The antennæ very dark brown; facial stripe and cheeks very dark brown; facial stripe and cheeks shining black; ground color of face black, plainly apparent beneath the light, irregular pollen and sparse brownish yellow pile; pile on front and vertex fulvous. Thorax wholly dark shining brown, color obscured by dense, reddish or fulvous pile. Scutellum similar in color and pile. Abdomen black, a rather large, shining, strongly reddish spot on either side of the second, and usually a similar, smaller spot on either side of the third segment. Fourth segment wholly black. Opaque bands nearly as in the female. Legs as in the female, except that the hind femora are entirely black, with the exception of the narrow apices. Wings similar. Length: 9–12 mm.

The male of *rupium* has been discussed under *temporalis;* its reddish color, stigmal spot, and spots on (usually) both second and third segments, characterize it; *nemorum* (male) resembles it in reddish coloration, but has the wings practically hyaline. The female of *rupium* is in strong contrast to the male, the former being largely shining black with no reddish spots on the abdomen. It can be confused only with the female of *obscurus*. Long series of *obscurus* show the degree of infuscation of the wings to be quite variable. However, the infuscation of this species will be found to be lighter and not so sharply marked as in the other species. The antennæ of *rupium* are brown to reddish, in the other, black. Further this form has the hind tarsi basally reddish to yellowish; they are black in *obscurus*.

Recorded from British Columbia by Dr. R. C. Osburn. I have additional British Columbian specimens, seven females from Wallface, New York (A. S. Nicolay), one female from Moss Pond, New York (R. C. Shannon), as well as European specimens.

Eristalis obscurus Lw.

Male. Antennæ black. Facial stripe and cheeks shining black; ground color of face black, slightly pollinose, sparsely yellowish white pilose. Thorax dark greenish black; moderately shining. Scutellum brownish; shining. Pile of thorax nearly wholly pale yellowish; abdomen black, with a pale yellowish white spot on either side of second segment; but slightly shining, more so on third and fourth segments. An opaque band on the posterior margin of the segments, often wanting on the fourth; a similar band on the anterior margin, narrower and produced posteriorly to form a kind of median triangle. Pile of anterior half of second segment and posterior part of fourth nearly white, on remainder of abdomen black.

Infuscation of wings never very great, but always present, diffused more or less over the whole basal two-thirds of the wing on the anterior half. Length: 8–13 mm.

Female. More shining. Spots of abdomen always obsolescent. The female might be confused with that of *nemorum*, the differences with which have been considered under that species.

This form, *obscurus*, of which I have studied a large series collected by Professor J. S. Hine in Alaska, is evidently a distinct one. It presents one or two little discrepancies from the original description. The antennæ of the species are described as reddish ferriginous and also the base of the hind femora as yellowish; the types were males. These two characters are applicable also to the females of *rupium*, but not to the males. I find seven or eight specimens of what I have considered *obscurus* with the bases of the hind femora yellowish in a varying degree; the antennæ are black. The antennæ and face of *inornatus* are likewise described as reddish to ferruginous; the type was a single poorly preserved female. May not Loew have had either *rupium* or *nemorum* or some other European species before him when he described *obscurus* and *inornatus?* My specimens of *obscurus*, so called, are a good species and I have called it this for the present. A study of the types will be necessary to clear the matter up.

Some seventy or eighty specimens, from Alaska, taken by Professor Hine, have been studied.

Eristalis nemorum Linne.

Male. First and second joints of antennæ shining black; third joint reddish to dark brown. Facial stripe and cheeks shining black. Ground color of face black, obscured by dense yellow pollen and pile. Thorax dark brownish black, but moderately shining; dull or obscure spots or bands can usually be made on the dorsum. Scutellum lighter, reddish brown. Pile of thorax, thick, short, and strongly reddish or fulvous, occasionally deep yellow. Abdomen black, second segment with a conspicuous, light reddish brown spot on either side; third segment usually with similar though smaller spots. Third and fourth segments shining, with an opaque band both anteriorly and posteriorly, the former often produced posteriorly in the form of a faint median dash. Legs as in the general type. Wings practically hyaline, faintly infuscated on the stigmal area.

Female. Differing considerably from the male; there are usually traces of the abdominal spots remaining on the second segment; dark reddish brown; the infuscation of the wings more noticeable and greater in extent; not so conspicuously reddish brown as in the male; more shining, etc. Length, 10.5–12.5 mm.

Closest to the female of *obscurus* but distinguished by the brownish to slightly reddish antennæ, yellow pile of face and the brownish to fulvous pile of the thorax.

Recorded by Dr. R. C. Osburn from this country, Journal N. Y. Ent. Soc. XXIII, 144. Additional specimens from Portland, Oregon (Binswanger), Teulon, Manitoba (Hunter and Cummins), and Moscow Mts., Idaho (R. C. Shannon).

Eristalis inornatus Lw.

This species has been reported several times since being described, but with very doubtful determination. Certain of these species examined by the writer, have turned out to be *rupium*, *nemorum*, etc. I should not be greatly surprised if *inornatus* represented one of the above species in some of their variations, or sexual forms.

I have seven specimens separated from a series of *obscurus*, and mentioned under that species, all of which agree among themselves in having the base of the hind tibiæ reddish to yellowish, in varying degree, slightly larger in size, etc.; their antennæ black. The species *inornatus* was described from a female, with reddish hind femora basally, but likewise with ferruginous antennæ; the face was said to be longer, the tubercle less prominent, than in *obscurus;* both these species were described by Williston as similar to *E. dimidiatus*. Like *obscurus*, a study of the type is necessary before definite conclusions may be attained. Both this species and *obscurus* were described from the Red River of the North. The length of the former was given as 13 mm.

Recently a species has been described within this group from Colorado, by Mr. E. E. Wehr (Univ. Studies, Vol. XXII, p. 151, 1922). The form, which he called *nitidus*, is of doubtful relationships; from a perusal of the description, as I have not been afforded opportunity to examine a paratype, it would seem probably nothing more than one of the European forms that have confused our American species. The name is preoccupied by Van der Wulp from an East Indian species.

THE OBSOLETUS GROUP.

(Group description.)

The obsoletus group contains a small number of species, at first sight rather dissimilar, but with more study, appearing somewhat closely related. Of the five species which I have seen and placed within this group, all are of large size, stout and robust build. A brief description of their characters, and the points on which they agree, follows.

Antennæ always broadly oval, but little longer than broad; normal in size; arista bare; bristle of second antennal joint unusually strong and prominent. Eyes unusually hairy for an *Eristalis;* the pile, while extensive, is usually lacking or short, on the lower third. Eyes of female narrow to widely separated. Face very sparsely pilose, and thinly pollinose; facial stripe ill defined, and usually limited to the central knob, or tubercular prominence. Thoracic dorsum opaque, or very feebly shining, practically unicolorous, with usually but faint indications of vittæ or fascia. Scutellum opaque, sometimes polished on the rim. Abdomen short and stout, generally highly shining; frequently unicolorous, sometimes obscurely marked with brown or black; segments with the usual, narrow, posterior, yellow marginal bands, frequently wanting only on the second segment, entirely lacking only in *tenax*. Hind femora usually considerably thickened, rarely slender. Hind tibiæ notably flattened and arcuated, with the lower (outer) surface, densely lined with a row of long, stiff hairs.

The flattening of the tibiæ is found to a slight extent in several groups of the genus, but never to so marked an extent. This is likewise true of the ciliated hind tibiæ. In such species as *obscurus*, *pilosus*, etc., the hind tibiæ are merely sparsely and loosely haired and may then be described as only pilose; in *albifrons*, *pusillus*, etc., a definite row of more loose, quite short bristles or hairs may be found, thus more or less intermediate between the two conditions, but not to be confused with the ciliate tibiæ of the present group. *E. vinetorum*, of the *albifrons* group also has the tibiæ as in this group. Wings usually nearly or entirely hyaline; sometimes with a dark blotch or spot near the middle.

Eristalis tenax, while plainly belonging here, shows several differences. The eyes are banded with two rows of hairs; the abdomen is neither so broad nor so short. *Eristalis mirabilis* while agreeing well with most of the characters above, has the thorax rather strongly banded in some lights. These are, however, rather vague and obscure as compared with members of

the *albifrons* or *scutellaris* groups. Finally, *ruficeps* differs markedly in the type of face, although agreeing well otherwise; in profile it is seen to be considerably swollen, yet evenly rounded with the facial prominence practically absent; very slightly excavated below the antennæ.

KEY TO THE SPECIES OF THE *Obsoleta* GROUP.

1. Face and thorax black......................................*pygolampus* Wied.
   Thorax brown to reddish or yellowish, never black........................2
2. Thoracic dorsum entirely yellowish to reddish brown.....................3
   Thorax with indistinct transverse fasciæ..................................4
3. Pile of thorax light yellow; third joint of antennæ dark brown or black...... *tenax* Linne.
   Pile of thorax reddish; third joint of antennæ light reddish brown...........5
4. An obscure, transverse, black band before the suture; wings with a large brown spot near the middle; pile of front and vertex.............*mirabilis* n. sp.
   No such black band on the thorax; wings only slightly infuscated; pile of front and vertex light...*obsoleta* Wied.
5. Prominence of face indistinct; face swollen, evenly rounded; hind femora not thickened; all the femora nearly all black..................*ruficeps* Macq.
   Tubercle of face prominent; face not evenly rounded; hind femora considerably thickened, usually reddish...............................*obsoleta* Wied.

Eristalis pygolampus Wied.

Male, female. Antennæ dark reddish brown; arista of the same color. Ground color of face black, covered with a scanty, dark brown pollen and a very few moderately long, golden hairs, sometimes whitish. Pile of front more abundant, black at vertex and just above antennæ, yellow between. Facial stripe and cheeks shining black. Thorax opaque, velvet black; in one somewhat teneral specimen, there are very faint fasciæ anteriorly, and posteriorly shining, with a bluish cast. Scutellum deep red, opaque, shining on the rim. Abdomen shining black, more brassy on the third and fourth segments, marked by opaque black as follows: Second segment with a median anterior spot and a posterior marginal band; third segment with a similar, smaller spot and a narrower posterior band. Third and fourth segments with a narrow, posterior, marginal band, widened medianly, of an opaque yellow, pollinose nature. Femora shining black, black haired; hind tibiæ black. Front and middle tibiæ and all the tarsi, light brownish or reddish yellow, yellow haired. Wings nearly hyaline, with a large brownish black spot in the middle. Length, 12–14 mm.

Three specimens. Itaquaquecetuba (F. R. Cole), Brazil; Bartica, British Guiana; Sao Paulo, Brazil.

The single male is slightly teneral; the common, "white pollinose line" of the thorax, mentioned in the original description is obscurely present, but with not a trace of it present in the two females. The yellow of the front, as described, seems normally to extend over only the small, bare, calloused area, present above the antennæ commonly within the genus.

Eristalis tenax Linne.

Male, female. Little need be said of this common and cosmopolitan species, save in a comparative way with the other members of its group. While of the same broad, stout form, its appearance is changed by the more flattened abdomen and more deeply projecting face. The only species of the group with a complete facial stripe and likewise with heavy pruinescence on the face. Antennæ dark brownish black. Cheeks black; facial stripe, shining, very dark brown. Pruinescence of face, pale yellowish brown. Thorax opaque dark brown, sometimes slightly shining; not unicolorous as apparent at first sight; a very obscure, wide, darker stripe, may be seen on either side of the thorax, broken at the suture, apparent in many specimens. Pile very dense, but short, pale brown. Abdomen shining, dark brown, almost black, with a light, oval, yellowish brown spot on either side of the second segment, frequently obsolescent. In a varietal form, the whole basal half of the third segment of the male, is similarly colored, narrowly interrupted medianly with black. In the female it is confined to a slender, transverse, medianly interrupted band, in the middle of the segment. Legs dark brown; basal third of front and hind tibiæ, and larger part of middle tibiæ and first two joints of middle tarsi, pale yellowish; front and hind tarsi, and last three joints of middle tarsi, dark brown. Wings nearly hyaline, sometimes faintly clouded in the middle. Length, 12–15 mm.

A universally common species, yet oftentimes local, due probably to the nature of its breeding places.

Eristalis mirabilis n. sp.

(Plate II, Fig. 11.)

Female. Antennæ dark brownish red. Facial spot shining reddish brown. Cheeks shining black. Ground color face reddish brown. Pruinescence of face brownish yellow; pile whitish. Front dark brown, becoming black at the vertex, opaque except just before the antennæ; pile blackish. Thorax with rather prominent fascia for a member of the group. A band between the humeri, dark brown, opaque; immediately behind, a narrow black band, followed by the narrow, obscure, interrupted white line before the suture. Behind the suture, a wide black band. Remainder of thorax, shining grayish black. Scutellum opaque, light reddish brown, shining on the rim. Pile of thorax and scutellum strongly brownish red. Abdomen shining black, marked by opaque black as follows: a median band on the second segment continuous posteriorly with a marginal band of the same width; third segment with a small median spot and posterior margin with a band; fourth segment with marginal bands, anteriorly and posteriorly. All the femora and hind tibiæ, shining black; anterior and middle tibiæ dark brown; all the tarsi light brownish red. Wings slightly tinged with brown, with a large brownish black spot in the middle. Length 15 mm.

Type, one female, Vista Nieve, Columbia. Nov. 16, 1922. (H. L. Viereck). Type in the collection of C. H. Curran.

In some respects resembling pygolampus, but differing in the color of the face and scutellum, bands of thorax, pile of thorax, etc.

Eristalis obsoletus Wied.

Male, female. Antennæ dark to light reddish brown; facial spot of the same color. Cheeks and ground color of face shining black, the latter sometimes nearly bare, usually obscured by dense, pale pruinescence; pile of face whitish. Pile of face and front very variable. In the males, pile of face rather abundant, golden; of front, above antennæ, yellow, intermixed with black, sometimes wholly black; of vertex golden. In the females, the pile of front and face is very thick, often wholly pale yellow; sometimes very largely black on front and vertex. Thorax very dark, opaque brown, heavily obscured by pile, in some cases bright fulvous, again light brownish yellow. Scutellum opaque, light reddish brown, shining on the rim; pile of the same color. Thorax nearly unicolorous, only the pale interrupted, sutural lines being present. Abdomen shining, dark brownish black, a large light brownish red spot on either side of the second segment; narrow, yellow, posterior marginal bands of segments often unusually prominent. In the male, conspicuous bands of black pile posteriorly, on segments two, three and four, are contrasted with bands of pale yellowish pile, anteriorly; sometimes abdomen wholly yellow pilose. Narrow bands of opaque black, on the posterior margins of the same segments, and a similar, small median spot, on the anterior margins of third and fourth segments. In the female the pile is usually wholly yellow, never with conspicuous bands of black and yellow pile. Light spots of second segment frequently obsolete. Two male specimens are considerably smaller, very dark, with the shining bands of the third and fourth segments very metallic. In the males the femora are wholly shining black, with the exception of the narrow apices; hind tibiæ black, narrowly pale yellowish basally; front and middle tibiæ brown, yellowish basally; tarsi light reddish brown, pile golden. Legs of female shining red, femora rarely black, paler on the tibiæ and tarsi; bases of tibiæ pale yellowish. Hind femora strongly thickened. Wings nearly hyaline, with a small brown spot near the stigma, sharply delimited basally. Length, 10–15 mm.

A very variable species. Nearly thirty specimens, from Guatemala; Chapada, Sao Paulo, Brazil; Yucatan, Mexico; Bartica, British Guiana. Also numerous specimens from San Diego, and Mill Creek Canyon, San Bernardino Co., California. (F. R. Cole).

Eristalis ruficeps Macq.

(Plate II, Fig. 10.)

Female. Head very large; face swollen. Antennæ light brownish red. Face and front very wide, the former light reddish brown; front slightly darker, vertex blackish. Pile of face abundant, pale yellowish brown, darker and more reddish on front and vertex. Cheeks shining black. Facial spot small, prominence practically lacking; face in profile evenly rounded, very slightly retreating below the antennæ. Thorax practically unicolorous, dark opaque brown, obscured by very dense, reddish pile. Scutellum, light brownish yellow, wholly opaque; pile concolorous. Abdomen shining black, with a more or less quadrate, reddish brown spot on either side of the second segment. Second segment with a wide, black, opaque band medianly, and a similar band on the posterior margin. Similar narrow bands, on the anterior and posterior margins of the third and fourth segments. Hind femora slender; all the femora shining black, narrow apices of anterior and middle pairs, yellow. Hind tibiæ black, narrowly yellow basally; all the tarsi and the remaining tibiæ, dark brown, the latter basally yellowish. Length, 18 mm.

One female. Coroico Yungas, Bolivia. April 5, 1899. (Ohio State University Collection.)

The Arbustorum Group.

(Group description.)

A small group; species medium to large in size. Antennæ oval in shape, slightly longer than broad; arista bare to short plumose. Eyes densely and long pilose; rather broadly separated. Facial stripe well developed in some; again obsolescent. Face long pilose, though not especially densely; sparsely to heavily pruinose. Thorax nearly opaque, but feebly shining, occasionally more highly, for a short distance in front of the scutellum; nearly unicolorous, marked by obscure spots or bands. Scutellum dark in color; moderately shining. Abdomen largely black, marked to a greater or less degree with yellowish brown or red, basally; of the usual shape. Hind femora quite slender; hind tibiæ normal, or slightly flattened. Wings hyaline.

A group not very sharply separated from the members of the *dimidiatus* group, yet the latter is rendered much more sharply characterized by their removal. The species, while generally opaque on the dorsum of the thorax, they are somewhat shining at the extreme posterior. The species are slightly longer pilose than usual, but are still much shorter than in the

pilosus group, and should not be confused with them on that account.

I have seen only four species falling here. It is most nearly approached within the *dimidiatus* group, by *nemorum*. Although *assimilis* and *bogotensis* are rather large in size, their tibiæ are quite normal.

KEY TO THE SPECIES OF THE *Arbustorum* GROUP.

1. Face protruding below the eyes for a distance equal to approximately the thickness of the eyes laterally; 12 to 14 mm. in length; unusually robust species. .2
   Face protruding below the eyes for considerably less than the thickness of the eyes laterally; 8 to 12 mm. in length. (See Figs. 12 and 14)................3
2. Second and usually third segment of abdomen with a large orange red spot... *assimilis* Macq.
   Spots usually confined to second segment; yellowish brown in color.......... *bogotensis* Macq.
3. Basal joint of middle tarsi yellowish except at tip; a transverse basal band of opaque black on fourth segment........................*arbustorum* Linne.
   Basal joint of middle tarsi entirely brown; fourth segment with a minute basal spot of opaque black or entirely shining (Fig. 4)................*brousi* Will.

Eristalis assimilis Macq.

(Plate I, Fig. 7; Plate II, Fig. 12.)

Male. Antennæ black. Facial stripe and cheeks shining black. Face reddish brown in ground color, slightly metallic in appearance; sparsely pollinose; pile pale in color. Pile of front and vertex black. Face rather deeply produced. Thorax opaque greenish black or brown, feebly shining, marked by four very obscure, broken, narrow stripes. Pile pale yellow. Scutellum shining, light yellowish brown. Second segment of abdomen bright reddish orange or fulvous, separated by a wide, opaque black median band, continued anteriorly along the greater part of the margin; the yellow broadly continuous on the third segment, separated medianly by a narrow, opaque black spot on the anterior margin, and a larger, metallic brassy black spot, posteriorly. Fourth segment metallic brassy, a narrow anterior marginal band, opaque black, produced to a small point medianly. Femora dark shining brown or black, apices narrowly yellowish; basal half of anterior and hind tibiæ, and larger part of middle tibiæ, pale yellow; tarsi dark brown or black. Wings hyaline.

Female. Similar to the male. Red of the abdomen confined to the second segment, and very narrowly basally, on the third. Median black band of second segment deeply concave on either side. Length, 14 mm.

Six or eight specimens. Arequipa, Peru. Ohio State University collection.

Eristalis bogotensis Macq.

(Plate II, Fig. 15.)

Male. Face, antennæ, etc., practically the same as in the preceding species. Thorax, opaque greenish black or gray; three slender, obscure,

black stripes, the outer ones broken at the suture. Pile pale brownish yellow. Scutellum shining yellowish brown; subtranslucent. Second segment of the abdomen light brownish yellow on either side, a wide, opaque black stripe medianly, extended anteriorly along the larger part of the anterior margin. Third segment with a small yellow spot in the anterior corners, separated anteriorly by a slender, opaque black band along the anterior margin, produced medianly into a sharp point, and posteriorly by metallic black; a narrow black posterior, marginal band, opaque. Fourth segment wholly metallic black, except for a narrow opaque black band on the anterior margin, produced medianly to a point. Legs nearly as in *assimilis*.

Female. Similar to the male. Yellow of the abdomen confined to two rather small spots on the second segment, surrounded by black on all sides except laterally. Wings nearly hyaline; faintly brownish in the middle. Length, 11–14 mm.

Five specimens. La Paz, Bolivia; Puno, Peru. Previously recorded from Colombia, Bogota, Mexico. Ohio State University collection.

Eristalis arbustorum Linne.

(Plate I, Fig. 5.)

Male. Antennæ dark brown; arista short plumose. Cheeks shining black. Facial stripe a very fine line, usually lacking. Face densely pale yellowish pollinose and pilose. Face much less produced than in the two preceding species. Thorax dark opaque brown, somewhat shining a short space before the scutellum. Scutellum shining dark brown. Pile of thorax, thick, short, brownish yellow. Second segment of abdomen yellow on either side, separated by opaque black medianly, extended anteriorly along the greater part of the margin, sharply cut off posteriorly and not quite reaching the posterior margin. The yellow of the second segment extends broadly on the third, but reaching as much as two-thirds of the length of the segment, only at the extreme edge, sometimes continuous the whole length, and with the narrow yellow posterior margins of the segment. Thus the black of the third segment forms more or less of a large, anteriorly truncate, triangle, the base on the posterior margin, the remaining two sides usually concave. Third segment with a metallic cross band in the middle, very slenderly interrupted medianly. Fourth segment opaque black, a broad, interrupted, metallic cross band in the middle, leaving distinct but narrow, transverse, opaque black bands on the anterior and usually the posterior margins. All the femora black; apices narrowly yellowish. Basal half of front and hind tibiæ, and a somewhat greater extent of middle tibiæ, pale yellowish, otherwise black. Front and hind tarsi, last four joints of middle tarsi, and a slightly variable apical portion of the basal joint, blackish or dark brown. Wings hyaline, often with brown clouds in the middle.

Female. Similar to the male. The yellow spots confined to the second segment of the abdomen and somewhat smaller; the median

black band wider and considerably dilated posteriorly but not reaching the side margins. Third segment with a metallic cross band, narrowly separated medianly, and opaque black bands on both anterior and posterior margins. Fourth segment similar, with similar, slightly narrower, black marginal bands. Fifth segment wholly shining black. Length, 9–12 mm.

An excessively common species, introduced from Europe, that seems to have largely displaced, in most localities, the indigenous *E. brousi*. Specimens from New Jersey, New York, Connecticut and Ohio, etc.

Eristalis brousi Will.

(Plate I, Fig. 4; Plate II, Fig. 14.)

Practically the same as in *arbustorum*, differing as follows: Male. The velvet black of fourth segment restricted to a very small basal median spot, sometimes wanting, and an occasional trace of similar black in front of the yellow hind border.

The black band of the third segment is slightly less wide. Female. Segments three and four are completely shining save for an occasional very small median, basal spot of opaque black, and a slight trace of the same in front of the yellow hind border. Both sexes differ in the nature of the basal joint of the middle tarsi. In *brousi*, the whole joint is dark brown or black, as are the remaining joints, whereas in *arbustorum*, the greater basal part is yellow or light brownish yellow. Length, 9–12 mm.

Specimens from New Jersey, Quebec, Wyoming, etc.

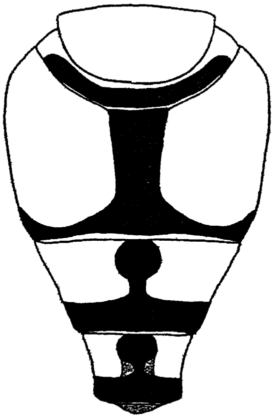
EXPLANATION OF FIGURES.

Plate I.

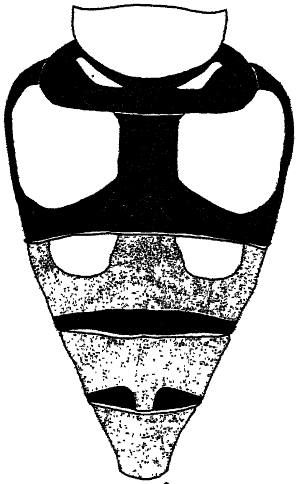
Drawings of Eristalis. Heavy stippling represents shining black; light stippling shining yellow. The scutellum of the species are somewhat distorted, especially in figures 4, 5, and 6. No pains have been spared to represent the abdomens themselves, and their markings, as accurately as possible. In Fig. 8 light stippling represents gray.

Plate II.

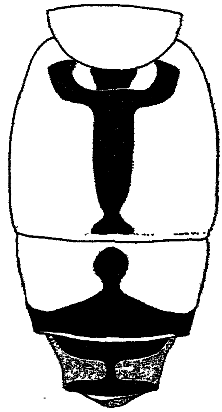
Drawings of Eristalis. Figures 11, 15 and 17 show the thorax; Fig. 18, the hind femora and tibiae; Figs. 19 and 20, view of head from above and in front respect; the remainder are profiles of the head. In Fig. 17 stippling represents aeneus; in 11 and 15 light stippling represents gray and dark stippling shining black.



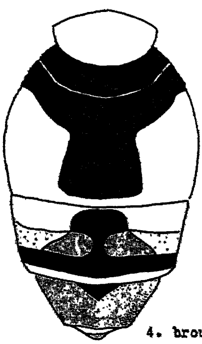
1. aemulus ♂



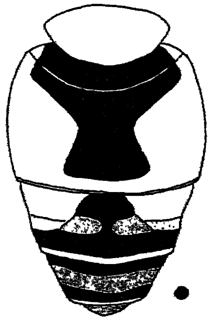
2. spectabilis ♀



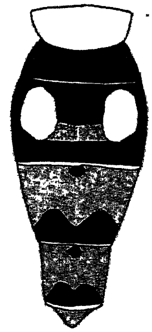
3. agrorum ♂



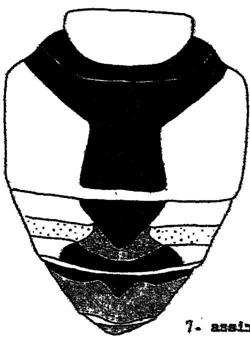
4. brousi ♂



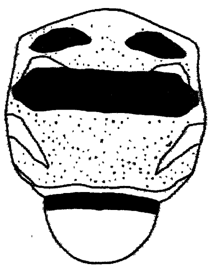
5. arbustorum ♂



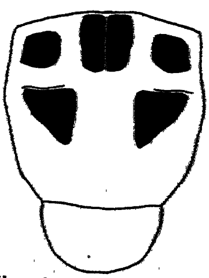
6. conicus ♀



7. assimilis ♂



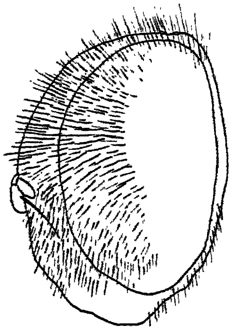
8. precipuus ♀

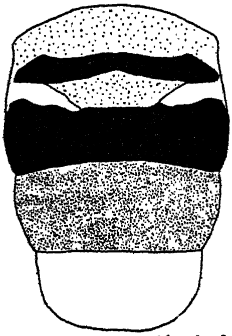


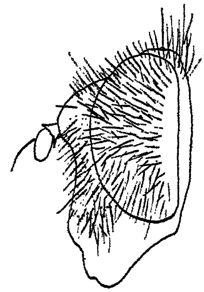
9. cyathens ♀

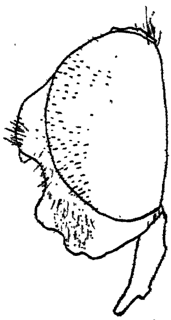
F. M. Hull del.

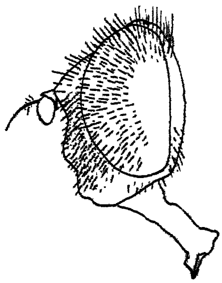
PLATE II

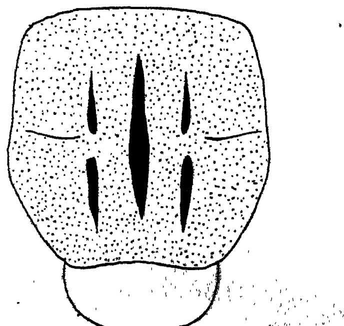

10.ruficeps ♀

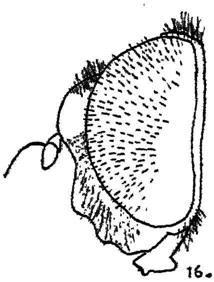

11.mirabilis ♀

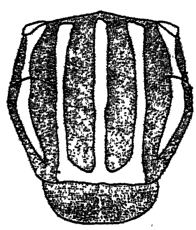

12. assimilis ♂

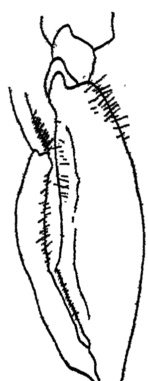

13.cyatheus ♀

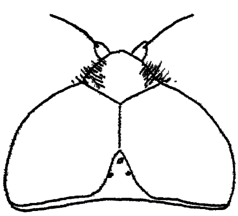

14.brousi ♂

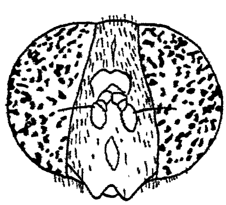

15.bogotensis ♀


16. scutellaris ♂


17. aeneus var.taphicus ♀


18.aemulus ♂


19.scutellaris ♂


20. aeneus ♀

F.M.Hull del.

APHIDS NEW TO OHIO.

C. R. CUTRIGHT
Ohio Agricultural Experiment Station

Since the publication of Guyton's list of Ohio Aphididæ (see *Ohio Journal of Science,* Vol. 24, pp. 1-30, 1924), several species new to Ohio have been collected by the writer. It is thought proper to publish these additions at the present time. The following list is modeled after that of Guyton and contains bibliographical references to the latest and most complete literature dealing with each species. Species not otherwise noted were collected by the writer.

LIST.

Anoecia corni (Fab.). *Aphis corni* Fab. Hemiptera of Connecticut, p. 258, 1923. On several species of dogwood (*Cornus*) and on roots of orchard grass (*Dactylis glomerata*) and red top (*Agrostis alba*), Wooster, Ohio, spring, summer, autumn, 1924; Columbus, Ohio, October 15, 1923.

Dilachnus pinicola (Kalt.). *Lachnus pinicola* Kalt. *Lachnus abietis* Fitch. Hemiptera of Connecticut, p. 262, 1923. Norway spruce (*Picea excelsa*), Wooster, Ohio, spring, summer, autumn, 1924.

Eulachnus agilis (Kalt.). *Lachnus agilis,* Kalt. *Lachnus rileyi* Wm. Hemiptera of Connecticut, p. 270. Austrian pine (*Pinus Laricio* var. *nigricans*). Wooster, Ohio, September 15, 1923.

Euceraphis betulae (Koch). *Callipterus betulae* Koch. Jr. Ec. Ent., Vol. 10, 1917, p. 425. Red birch (*Betula nigra*), Wooster, Ohio, August 4, 1924.

Rhopalosiphum rubiphilium (Patch). *Aphis rubiphila* Patch. Me. Agri. Exp. Station Bull. 233, p. 269, 1914, on black raspberry (*Rubus occidentalis*), Catawba Island, Ohio, June 12, 1923.

Amphorophora cosmopolitana Mason. *Amphorophora lactucæ* (Kalt.). *Rhopalosiphum lactucæ* (Kalt.). *Aphis lactucæ* Kalt. Maine Agr. Exp. Station Bul. 225, p. 53. On black currant, *Ribes nigrum,* Wooster, Ohio, June 8, 1925.

Amphorophora sensoriata (Mason). Proc. Ent. Soc. of Washington, Vol. XXV, No. 9, p. 188, 1923. Canes of black raspberry (*Rubus occidentalis*), Lucasville, Ohio, July 8, 1924. R. B. Wilcox, Coll.

Capitophorus carduinus (Walk.). *Phorodon carduina* Walk. A Synopsis of the Aphididæ of California, Swain, p. 73, 1919, on Canada thistle (*Cirsium arvense*), Wooster, Ohio, October 13, 1924. Dr. Freda Detmers, Coll.

Capitophorus elægni Del Guercio. Jr. Ec. Ent., Vol. 8, pp. 375-379, 1915, on silverberry (*Elægnus parvifolia*), Wooster, Ohio, November 2, 1922.

Capitophorus. An undetermined species on raspberry (*Rubus occidentalis*), Wooster, Ohio, June, July, August, 1924. R. B. Wilcox, coll. This is one of the species concerned in the transmission of the mosaic disease of raspberry.

Tetraneura graminis Mon. *Tetraneura colophoidea* Howard. *Tetraneura ulmicola* Gill. Hemiptera of Conn., p. 316. Me. Agri. Exp. Station, Bull. 181, on American elm (*Ulmus americana*), Wooster, Ohio, July 15, 1920. P. R. Lowry, coll.

Pemphigus populi-caulis Fitch. Hemiptera of Conn., p. 327, 1923. On cottonwood, *Populus deltoides,* Chillicothe, Ohio, June 20, 1925. A. E. Miller, coll.

Asiphum pseudobyrsa (Walsh). *Byrsocrypta pseudobyrsa* Walsh. Ent. News, v. 25, pp. 269-275, 1914. Hemiptera of Conn., p. 321, 1923. On cottonwood, *Populus deltoides,* Chillicothe, Ohio, June 20, 1925. A. E. Miller, coll.

Neoprociphilus aceris (Monell). *Pemphigus aceris* Monell. Hemiptera of Connecticut, p. 324, 1923. On branches of sugar maple (*Acer saccharum*), Wooster, Ohio, July 9, 1922.

Prociphilus erigeronensis (Thos.). *Trama erigeronensis* Thomas. Me. Agri. Exp. Station Bull. 270, p. 46, 1918. On roots of many Compositæ and other plants. Wooster, Ohio. Throughout the year 1924.

Geoica radicola (Essig). *Trifidaphis radicola* (Essig). *Pemphigus radicola* Essig. U. S. Dept. of Agriculture Bull. 826, p. 79, 1920. Roots of bean (*Phaseoli vulgaris*) and many Compositæ. Throughout the year 1924. Wooster, Ohio.

Chermes strobilobius Kalt. Insects affecting Park and Woodland Trees, p. 187. On larch (*Larix laricina* or *europaea*), Wooster, Ohio, May 10, 1924.

Chermes abietis Linn. Me. Agri. Exp. Station Bull. 173, p. 290. On Norway spruce (*Picea excelsa*). Chagrin Falls, Ohio, September 21, 1924. Dr. H. R. Cooley, coll.

INDEX TO VOLUME XXV.

Academy of Science Meeting........................151
Additions to the Catalog of Ohio Vascular Plants for 1924........ 130
ALEXANDER, W. H........................151
Aphids New to Ohio........................313
A Review of the Genus Eristalis Latreille in North America........ 11; 285
A study of the Cestode Parasites of the Black Bass in Ohio, with Special Reference to Their Life History and Distribution........................255

BANGHAM, RALPH V........................255
Bass, Cestode Parasites of........................255

Carrot Family in Ohio........................271
Catalog of Ohio Plants for 1924........................130
Cestode Parasites of the Black Bass........................255
CHAMPION, MILTON M........................ 51
Chicony Family in Ohio........................ 85
Crop Ecology and the Primary Vegetational Survey........................ 1
CUTRIGHT, C. R........................313

Debarya, The Genus........................193
Description of Fourteen Undescribed Species of Parthenicus........................119
Digestive Enzymes of An Insect........................209
Digestive Tract of Longistigma Caryae........................244

Ecology and the Primary Vegetational Survey........................ 1
Enzymes of an Insect........................209
Eristalis Latreille, the Genus, in N. America........................11; 285

FINK, BRUCE........................ 99
Food Habit Ratios in Death Valley........................244
Four Undescribed Species of Waterstridus........................ 46

Glacial Material Beyond the Border of the Drift in Ohio........................ 97

Hemiptera........................46; 114
Hemp, Sex Reversal in........................172
HENDERSON, NELLIE F........................85; 177; 271
HICKS, CLIFFORD........................ 97
HINE, JAMES S........................190
History of Five River Valleys in Northern Ohio........................ 51
HOTTES, F. C........................ 46
HUBBARD, GEO. D........................ 51
HULL, F. M........................11; 285

Influence of the Substratum on the Percentage of Sex Reversal in Hemp........172
Insect Food Habit Ratios in Death Valley and Vicinity........................253

KNIGHT, HARRY H........................119
KNOWLTON, GEO. F........................244

McCLURE, F. A........................114
Mosses, Ohio Polytrichiales........................177

Notes on the Occurrence of Glacial Material Beyond the Border of the Drift in Muskingum County, Ohio........ 97

Ohio Academy of Science Meeting........ 151
Ohio Mosses, Polytrichiales........ 177

Parasites, Cestode, of the Black Bass........ 255
Parthenicus, (Hemiptera) Undescribed Species of........ 114
PATTON, LEROY T........ 97
Physiographic History of Five River Valleys in Northern Ohio........ 51
Plant Collector on the Island of Hainan........ 114
Plants, Ohio Vascular of 1924........ 130
Plant Taxonomy........ 219
Polytrichiales, Ohio........ 177
Principles of Plant Taxonomy, II........ 219
Protoplasm, Some Considerations of........ 99

Report of the Thirty-fifth Annual Meeting of the Ohio Academy of Science........ 151
Review of the Genus Eristalis Latreille........ 11; 285

SEARS, PAUL BIEGLOW........ 139
SCHAFFNER, J. H........ 130; 172; 183; 219
Sex Reversal in Hemp........ 172
Some Considerations of Protoplasm........ 99
Some Observations of a Plant Collector on the Island of Hainan........ 114
Survey, the Primary Vegetational........ 1
Synopsis Considered as a Sexual Phenomenon........ 185
Swingle, H. S........ 209

Tachopteryx Thoryi Recorded for Ohio........ 190
Taxonomy, Principles of Plant........ 219
The Carrot Family in Ohio........ 271
The Chicory Family in Ohio........ 85
The Digestive Tract of Longistigma Caryae........ 244
The Dragonfly, Tachopteryx Thoryi, Recorded for Ohio with Notes of Its Near Relatives........ 190
The Genus Debarya........ 193
The Influence of the Substratum on the Percentage of Sex Reversal in Winter Grown Hemp........ 172
The Natural Vegetation of Ohio........ 139
The Genus Eristalis, a Review........ 11; 285
TRANSEAU, EDGAR NELSON........ 193

Vegetation, Natural of Ohio........ 139
Vegetational Survey and Crop Ecology........ 1

WALLER, A. E........ 1
Waterstriders, Four Species of........ 46
WEISS, HARRY B........ 253

Date of Publication: November 23, 1925.